This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

+ *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.

+ *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.

+ *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.

+ *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at `http://books.google.com/`

BERKELEY
LIBRARY
UNIVERSITY OF
CALIFORNIA

EARTH
SCIENCES
LIBRARY

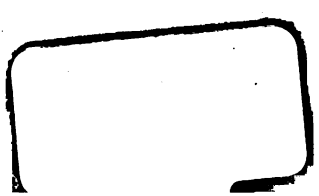
UNIVERSITY OF CALIFORNIA.

FROM THE LIBRARY OF

DR. JOSEPH LECONTE.

GIFT OF MRS. LECONTE.

No.



Vol. I

WEST VIRGINIA
GEOLOGICAL SURVEY

WEST VIRGINIA
GEOLOGICAL SURVEY

VOLUME ONE

MAGNETIC DECLINATION, By R. U. Goode
Geographer, U. S. G. Survey.

ADMINISTRATIVE REPORT
LEVELS ABOVE TIDE
PETROLEUM AND NATURAL GAS
By I. C. White, State Geologist.

LIBRARY OF THE UNIVERSITY OF CALIFORNIA

MORGANTOWN.
THE POST PRINTING HOUSE.
1899.

QE177
A4
v.1

EARTH
SCIENCES
LIBRARY

COMMISSION

GEORGE W. ATKINSON, - - - PRESIDENT.

GOVERNOR OF WEST VIRGINIA.

M. A. KENDALL, - - - - - TREASURER.

TREASURER OF WEST VIRGINIA.

JEROME H. RAYMOND, - - - - -

SECRETARY AND EXECUTIVE OFFICER.

PRESIDENT OF THE WEST VIRGINIA UNIVERSITY.

S. W. ATKINSON, - - - - - - -

PRESIDENT, STATE BOARD OF AGRICULTURE.

JAMES H. STEWART,

DIRECTOR, STATE AGRICULTURAL EXPERIMENT STATION.

SCIENTIFIC STAFF

I. C. WHITE, - - - STATE GEOLOGIST.
SUPERINTENDENT OF THE SURVEY.

S. B. BROWN, CURATOR OF COLLECTIONS AND ASSISTANT.

B. H. HITE, - - - - - CHEMIST.

RUSSELL L. MORRIS, - - - DRAUGHTSMAN.

JOHN M. GREGG, - - - - CHIEF CLERK.

LETTER OF TRANSMITTAL

To His Excellency, GEORGE W. ATKINSON, Governor of West Virginia, and President of the Geological Survey Commission.

SIR :—I have the honor to present herewith the first volume of the West Virginia Geological Survey. Millions of dollars are annually expended within the State in the search for petroleum and natural gas, hence the State Geologist considered that his first duty was to give to this great expenditure all the aid and direction that geology can supply. It is much to be regretted that the financial resources of the Survey would not permit of any illustrations for this volume, or even a proper discussion of the vast body of facts available in the study of questions connected with the petroleum and natural gas industries.

The new State map drawn under my supervision by Mr. Morris has been published separately from this volume, and the distribution of the 3,000 copies ordered began February 4th.

The active work of the survey must cease with the publication of this volume, until the Commission is provided with additional financial resources, since there remain only sufficient funds to meet the cost of publishing 3,000 copies of this report.

The material for the second volume which was planned to contain the report on Coal by the State Geologist, and the Bibliographic Memoir by Prof. S. B. Brown, is practically all in hand, and could be made ready for publication at small cost, whenever funds are available.

Very respectfully,

I. C. WHITE,
State Geologist.

Morgantown, March 20th, 1899.

CONTENTS

	Pages.
Preface	IX-XIII
Errata	XIV
PART I.—REPORT OF GEOLOGICAL COMMISSION.	
Legislative Act establishing the Survey	1-3
Organization of Commission, and business meetings	3-7
Annual Report of the State Geologist	7-26
PART II.—LEVELS ABOVE TIDE.	
Baltimore & Ohio Railroad and Branches	27-32
Monongahela River Railroad	33
West Virginia and Pittsburg Railroad	34-35
Grafton and Greenbrier Railroad	35
West Virginia Central and Pittsburg Railroad	35-38
Ohio River Railroad	38-41
Little Kanawha River Levels	41
Chesapeake and Ohio Railroad	42-44
Elk River Levels	44
Gauley River Levels	44
Norfolk and Western Railroad	45-47
Kanawha and Michigan Railroad	47
Pittsburg, Wheeling and Kentucky Railroad	47-48
Pittsburg, Washington and Southern R. R. Survey	48-49
West Virginia Short Line Railroad Survey	50-53
PART III.—VARIATION OF THE MAGNETIC COMPASS.	
Establishment of True Meridian marks in each county of the State by the U. S. G. Survey	54-122
Letter of Director Walcott, transmitting report on magnetic work	54-55
Discussion of Magnetic Declination, by R. U. Goode, Geographer, U. S. G. Survey	55-66
Table of Magnetic Declination in the several Counties of the State	57-58
Instructions for determining a True Meridian	65-66
Detailed description of the Meridian Monuments and their location in the several counties, alphabetically arranged	66-122
PART IV.—PETROLEUM AND NATURAL GAS.	
Historical sketch	123-148

The early drilling operations of David and Joseph Ruffner in the Great Kanawha Valley, described by Dr. J. P. Hale 125-135
Dr. Hildreth's Account of the early Petroleum Industry 136-138
Early petroleum operations on the Little Kanawha and Hughes Rivers 139-141
Transactions in Petroleum of Bosworth, Wells & Co., of Marietta, Ohio 142-143
Invention of method for pumping wells from a Central Power plant 144
Petroleum operations at Burning Springs, Little Kanawha River 144-147
Why early drilling efforts failed to reach the deep oil sands... 147-148
Statistics of oil production in West Virginia 148-151
Statistics of oil production in Pennsylvania 151-152
Natural Gas production 153-154

Geology of Petroleum and Natural Gas.

Method of occurrence 155-157
Aids in locating Oil and Gas Pools 158-159
History of the Anticlinal Theory 159-178
Essence of the Theory 178-180
Relation of West Virginia Oil and Gas Pools to Geological Structure 180-182
Absence of Prominent Anticlinals south-west from Little Kanawha River 182
Necessary conditions for the existence of Oil or Gas in underlying strata 182-183
Effects of fissured strata 183-184
No Petroleum in Mountain Regions 184
The Significance of Degree Lines 184-186
Strike Lines safest to follow 186-187
Rock pressure in Oil and Gas Wells 187-197
Strata pierced in the Oil and Gas wells of West Virginia 197-231
Typical record of the strata in the Pennsylvania Oil Region, S. B. Phillips well No. 1, at McDonald, Pa 213-230
Oil well records in Monongalia county 230-237
" " " " Marion " 238-247
" " " " Harrison " 248-255
" " " " Lewis " 255-259
" " " " Gilmer " 259-261
" " " " Wirt " 261-263
" " " " Roane " 264-269
" " " " Braxton " 269-271
" " " " Kanawha " 271-273
" " " " Mason " 273-274
" " " " Cabell " 274-276
" " " " Mingo " 276-279
" " " " Lincoln " 279-281
" " " " Mason " 281-283
" " " " Jackson " 283-285

Oil well records in Wood county 285-299
" " " near Marietta, Ohio 286-288
" " " at Macksburg, Ohio, ... 298-299
" " " in Ritchie county 299-322
" " " " Doddridge " 322-334
" " " " Tyler " 334-338
" " " " Wetzel " 339-345
" " " " Marion " 345-348
" " " " Wetzel " 349
" " " " Marshall " 350-352
" " " " Pleasants " 352-354
" " " " Tyler " 354-356
" " " " Monroe county, Ohio..... 356-357
" " " " Tyler " 357-361
" " " " Marshall " 362-364
" " " " Ohio " 364-366
" " " " Brooke " 367-368
" " " " Hancock " 368-370
Oil and Gas Horizons of West Virginia..... 370-374
Character and Quality of West Virginia Petroleum..... 374-377
Table of Specific Gravities..... 375-376
"The Gordon Sand Group"..... 377-378

APPENDIX TO PART II.

Levels Above Tide.

Dry Fork Railroad..... 379-380
Guyandot Valley Railway 380-381
Charleston, Clendinnin & Sutton Railroad..... 381-382
Monongahela River Levels..... 383-389
Great Kanawha River Levels..... 390
Disagreement of Levels..... 391-392

PREFACE

Part I of this volume gives a full account of the inception and organization of the Survey. In addition, it outlines a plan for carrying on the work in a systematic manner, and of making a topographic map of the State which will be satisfactory (because accurate) when completed. The only geological surveys that meet the wants of all classes of people, are those based upon accurate topographic maps. For the truth of this proposition we do not have far to go. Pennsylvania on our northern boundary has had two State surveys, neither of which was based upon topographic maps; the result is that after a vast expenditure (amounting to nearly a million dollars for both surveys), her people are now clamoring for a third survey which shall give them this modern necessity for progressive peoples, viz., an accurate topographic map. Ohio, on our western boundary, simply repeats the story of Pennsylvania's experience, while Maryland, our progressive sister on the north-east, is now correcting the mistakes of the past, and by co-operation with the National Survey, is securing at small comparative cost this great boon, valuable to all classes of her citizens.

There is no State in the Union that would profit so much from the possession of a complete topographic map as West Virginia, and so great is the necessity for such a map as a basis for geological work that the present State Geologist cannot recommend the further appropriation of money for a Survey without pro-

vision being made for it at the same time. The benefits would come to all; to the small land-holder alike with the largest; to the merchant, the mechanic, the laborer; to the man with no capital alike with those who control millions. The men who argue that the large capitalists, and the corporations would receive a greater proportion of benefits than other classes, from the making of such maps at State expense, are entirely in error, for the very reverse of that proposition is the truth. The large capitalists make their own topographic maps, and employ their own experts to gather facts for private use, while the small capitalist can have no access to such information. It was due largely to this line of fallacious reasoning that the Legislature which has just adjourned was prevailed upon to make no provision for the topographic map recommended by the State Geologist and the Commission, and to refuse appropriations for the continuance of the Survey. Hence, with the publication of this volume, active work will come to an end, unless some future Legislature shall provide for its renewal.

The kind assistance of the several railroads of the State through their Presidents, and Chief Engineers, has enabled the Survey to publish the very complete lists of levels given in Part II, as also the appendix to same at the close of the volume. The U. S. Engineers have also contributed valuable data to this subject from the river surveys of the War Department.

The generous co-operation granted by Director Walcott of the U. S. G. Survey has enabled the Survey to present the people of the State with the valuable data on magnetic variation in every county, recorded in Part III, and also the interesting discussion of Mr. R. U. Goode, which accompanies the same, all at a merely nominal cost to the State.

For the data used in the preparation of Part IV on Petroleum and Natural Gas, the Survey is under especial obligations to nearly every Oil Company operating in the State, as well as to the individuals interested in petroleum and natural gas. These have without exception placed their log-books and records at the service of the Survey, and thus have furnished a much greater mass of valuable information than could be published in this volume. Where so many have rendered aid, it is impossible to mention all specially, but due credit is given in the text for all records and data used in the preparation of Part IV. The following list includes the principal firms and individuals who have thus aided the Survey :

The Associated Producers Oil Co., by its geologist, Prof. John F. Carll, The Atlas Oil Company, by its Secretary, F. J. Foster, the Battelle Oil Co. by its President, A. L. Lowrie, the Burt Oil Co. by its President, C. C. Burt, the Cairo Oil Co. by its Superintendent, W. K. Jacobs, the Carr Oil Co. by its President Wm. M. Carr, the Carter Oil Co. by its President John J. Carter and Engineer W. H. Aspinwall, the Chartiers Oil Co. by its President Joseph W. Craig, the Clark Oil Co. by its Superintendent Wm. A. Clark, the Devonian Oil Co. by Crawford and Wilson, the Elk Fork Oil Company, the Fisher Oil Co. by its President Mr. Fisher, the Forest Oil Co. by W. J. Young, Vice President, the Hartman Oil Co. by its President Mr. Hartman, the Henderson Oil Co. by its Superintendent, George L. Craig, the Henry Oil Co., by its late President Geo. W. Henry, and Engineer C. G. Elliott, Jennings Bros., Murphy and Jennings, and the Kanawha Oil Co., by E. H. Jennings, the Long Reach Oil Co., the McCalmont Oil Co. by its President,

David Kirk, the North American Oil Co. by its Vice President F. E. Boden, the Oxford Oil Co. by its President Jos. W. Craig, the Rockland Oil Co., the South Penn Oil Co. by its Vice President N. F. Clark, its General Manager Glenn T. Braden, and its District Manager John W. Worthington, the Spragg Oil Company by its President Dr. Spragg, the Sun Oil Co., the Union Oil Co., the United States Oil Co., by Greenlee and Forst, the Victor Oil Co. by Crawford and Wilson.

Among individuals furnishing valuable information concerning petroleum and natural gas may be mentioned William Cale, John T. Harris, C. T. Caldwell, John Garber, James Showalter, J. C. Rathbone, Brown and Logan, J. M. McCormick, Bettman and Watson, all of Parkersburg, N. W. Athey, and E. Harvey, of Williamstown, D. J. Riley, Prof. F. W. Minshall, and Tasker W. Bosworth, of Marietta, L. A. Brenneman, A. J. Yoke, John McMahon, Bartlett and Stancliffe, of Sistersville, Wm. A. Earseman of Pittsburg, T. J. Vandergrift, of Jamestown, N. Y., C. N. Payne, General Manager National Transit Co., and F. H. Oliphant, geologist, of Oil City, Pa., H. L. Scrafford of the Eureka Pipe Line Co., A. M. Douglas of Cairo, D. P. Gist of Hartford, Judge T. H. Harvey and J. L. Caldwell, of Huntington, Prof. T. M. Jackson, of Clarksburg, J. M. Guffey, Guffey and Queen, and Ira DeWitt of Pittsburg, C. F. Pontius of Petroleum, Roberts Bros., and D. A. Kreaps of Burning Springs, C. Brockunier of Wheeling, B. F. Meighen of Moundsville, George B. Walmer and A. W. Brown of New Cumberland, Messrs. Courtney, Lowrie and McDermott of Morgantown, Noble and Ross of Waynesburg, Pa., and many others.

The absence of an index from this volume is much to be regretted, but a choice had to be made between forty to fifty pages of index or a like amount of subject matter, and the latter was considered of more value than an index which is partially supplied by the Table of Contents, and the general arrangement of the volume by counties.

A word of explanation is necessary concerning two terms frequently used by drillers, viz., "shell," and "break." By "shell" is meant a very hard, sandy layer, too thin and fine-grained to be called a sandstone. The word "break" is generally of the same meaning as *slate*, with the additional idea included that the "break" or slate in question separates parts of what is often one solid stratum or formation.

The Survey is also under obligations for free transportation to the Baltimore & Ohio Railroad; the Ohio River Railroad; the Monongahela River Railroad; the West Virginia and Pittsburg Railroad; the West Virginia Central and Pittsburg Railroad; and the Chesapeake and Ohio Railroad.

ERRATA.

Page	69,	line	2	from bottom,	*for* "20° 11′ W."	*read* 2° 11′ W.
"	237,	"	7	" "	" "demonstrates"	" demonstrate.
"	253,	"	17	" top	" "Genuis Pagne"	" Genius Payne.
"	354,	"	15	" "	" "1900 feet"	" 1700 feet.
"	366,	"	11	" "	" "Wheeliny"	" Wheeling.

The levels at the several stations on the Fairmont, Morgantown and Pittsburg Railroad do not tally with the carefully-made levels of the Monongahela River Survey, by the U. S, Engineers. The table of elevations on this railroad, pages 32, should be corrected to agree with the Monongahela River Survey, pages 384 and 385.

LIBRARY OF THE UNIVERSITY OF CALIFORNIA

Part I.

REPORT OF STATE GEOLOGICAL COMMISSION TO THE LEGISLATURE,

CONTAINING AN ACCOUNT OF THE OPERATIONS OF THE SURVEY

During the Years 1897 and 1898.

The Commission designated under the Act of the Legislature passed February 26th, 1897, establishing a State Geological and Economic Survey, has the honor to submit herewith its report required by the same. The Act in question reads as follows:

An Act to establish a State Geological and Economic Survey and to make provision for the preparation and publication of reports and maps to illustrate the natural resources of the State, together with the necessary investigations preparatory thereto.

(Passed February 26, 1897. In effect from passage. Approved, February 26, 1897.)

Be it enacted by the Legislature of West Virginia:

1. That there is hereby established a State Geological and Economic Survey which shall be under the direction of a commission composed of the governor, the treasurer, the president of the West Virginia University, the president of the State Board of Agriculture, and the director of the West Virginia Agricultural Experiment Station, who shall serve without compensation, but shall be reimbursed for actual expenses incurred in the performance of their official duties; and the said commissioners shall have general charge of the survey, and shall appoint as superintendent of the same a geologist of established reputation, and such assistants and employes as they may deem necessary; and they shall also determine the compensation of all persons employed by the survey, and may remove them at pleasure.

2. That the survey shall have for its objects:

First. An examination of the geological formations of the State with especial reference to their economic products, namely: building stones and other constructive materials and resources; clays, ores, and other mineral substances and fuels, and the prevention of their waste, and the utilization of by-products.

Second. An examination and classification of the soils and a study of their adaptability to particular crops.

Third. An examination of the forests and timber lands of the State with reference to the economic utilization of the same, and the prevention of their waste.

Fourth. An examination of the physical features of the State with reference to their practical bearing upon the occupations of the people, the industrial development and the material prosperity of the several portions of the State, having due regard to their varying resources, conditions and needs.

Fifth. The preparation of special geological and economic maps to illustrate the resources of the State.

Sixth. The preparation of special reports, with necessary illustrations and maps, which shall embrace both general and detailed description of the geology and natural resources of the State.

Seventh. The consideration of such other scientific and economic questions as in the judgment of the commissioners shall be deemed of value to the people of the State, and the immediate establishing and the proper marking of the true meridian points in the several county seats of the State.

3. That the commissioners shall cause to be prepared a report to the Legislature before each meeting of the same, showing the progress and condition of the survey, together with such other information as they may deem necessary and useful or as the Legislature may require.

4. That the regular and special reports of the survey, with proper illustrations and maps, shall be printed as the commissioners may direct,

and that the report shall be distributed or sold by the said commissioners as the interests of the State, the diffusion of practical information relating to the development of the State, and the advancement of science may demand; and all moneys obtained by the sale of the reports shall be paid into the State treasury.

5. That all materials collected, after having served the purpose of the survey, shall be distributed by the commissioners to the educational institutions in such manner as to be of the greatest advantage to the educational interests of the State; or, if deemed advisable, the whole or part of such material shall be put on permanent exhibition.

6. That the sum of three thousand dollars annually, for the years One Thousand Eight Hundred and Ninety-seven and One Thousand Eight Hundred and Ninety-eight, or so much thereof as may be necessary, is hereby appropriated out of any funds of the treasury, not otherwise appropriated, for the purpose of carrying out the provisions of this act.

The first meeting of the Commission was held in the City of Wheeling, September 23rd, 1897, at which all the members were present, viz: Hon. George W. Atkinson, Governor of West Virginia; Hon. M. A. Kendall, State Treasurer of West Virginia; Dr. Jerome H. Raymond, President of the West Virginia University; Prof. T. C. Atkeson, President of the State Board of Agriculture, and Hon. James H. Stewart, Director of the West Virginia Agricultural Experiment Station. The organization of the Board resulted in the election of George W. Atkinson President, T. C. Atkeson Secretary, and M. A. Kendall Treasurer. Satisfactory by-laws and regulations were adopted for the transaction of the business of the survey, and Dr. Raymond was chosen Executive Officer of the Board and empowered to approve all bills before presentation for payment.

The office of the Survey was established at Morgantown, upon the offer of the West Virginia University and the West Virginia Agricultural Experiment Station to furnish suitable rooms free of all cost.

Dr. I. C. White, of Morgantown, was appointed Superintendent of the Survey, with the title of State Geologist, and his salary fixed at $2,000 a year.

Prof. S. B. Brown, of the State University, was appointed assistant geologist, and curator of collections at an annual salary of $250, and requested to prepare a bibliographical and historical sketch of all previous work on the geological and economic resources of the State.

Action was also taken with reference to the meridian work required by the act establishing the Survey, and the question of employing some one to do the work was referred to Dr. Raymond.

The Treasurer's bond was fixed at $10,000, and after authorizing that officer to make a draft upon the Auditor for $3,000 the Commission adjourned to meet at the call of its president.

The next meeting of the Commission was held at Morgantown, December 1st, 1897, at the request of the State Geologist, who had returned from Russia in November and formally accepted the office of Superintendent of the Survey. The former president of the State Board of Agriculture, Prof. T. C. Atkeson, having resigned that office, and Hon. S. W. Atkinson, of Brooke county, having been appointed to the vacancy, the latter gentleman was present as a member of the Commission, *ex officio*, together with Governor George W. Atkinson, Hon. M. A. Kendall, and Dr. Jerome H. Raymond.

After the correction and approval of the minutes of the Wheeling meeting, Dr. White, the State Geologist, appeared before the Commission and made a

statement of his plans for work during the ensuing year, in substance as follows:

(1). The authorization of a contract with the U. S. Geological Survey for the location and marking of the true meridians in every county of the State, at a total cost not to exceed five hundred ($500) dollars, the same to supercede the arrangement made by the Executive Officer with Prof. John L. Johnston in pursuance of action taken at the Wheeling meeting.

(2). The preparation and publication of a new map of the State to serve as a preliminary basis for geological and economic purposes.

(3). The preparation by the State Geologist of reports upon Petroleum, Natural Gas and Coal, and their publication within the limits of appropriations made.

(4). The employment of a suitable person to act as Chief Clerk of the Survey and do the principal part of the work which is now required of the Secretary of the Commission.

(5). The employment of a Chemist for the Survey at a nominal salary.

After thorough discussion the State Geologist was authorized to carry into effect the plans above outlined.

The Secretary of the Commission having resigned that office, Dr. Jerome H. Raymond was appointed to fill the same, and serve without salary at his own request.

Dr. White tendered the Commission the use of his office and fire proof vault free of charge as the temporary office of the Survey, which was accepted. He also requested that his salary should not begin

until January 1st, 1898, and this arrangement was approved.

The meeting then, after the transaction of some routine business, adjourned to meet at the call of its president.

The third meeting of the Commission was called for the City of Wheeling at the office of Atkinson & Flick, September 14th, 1898, and the following members were in attendance: Governor George W. Atkinson, Dr. Jerome H. Raymond and Hon. S. W. Atkinson. The State Geologist was also present and submitted a verbal report of the progress of the Survey, and also made a financial statement showing that the funds ($3,000) drawn from the State treasury on the warrant issued in September, 1897, had all been expended for the purposes of the Survey, except a balance of $20.46. The Commission thereupon authorized its treasurer to draw a warrant upon the Auditor for the unexpended balance of the appropriation ($3,000) carried by the Act, and after the transaction of other routine business, adjourned to meet at the call of its president.

The fourth and last meeting of the Commission at which this report was formulated, met on the call of the president, at Charleston, December 21st, 1898, the following members being present: Governor George W. Atkinson, Dr. Jerome H. Raymond, Hon. James H. Stewart, and Hon. S. W. Atkinson.

The State Geologist, Dr. White, was also present, and submitted a detailed report of expenditures with accompanying vouchers properly approved by the Executive Officer of the Commission. The accounts were duly examined, found to be correct, and to

agree exactly with the financial statement filed at the same time by the Treasurer of the Commission, Hon. M. A. Kendall, who was absent through sickness.

The State Geologist then submitted his annual report to the Commission, which is as follows:

Annual Report of the State Geologist.

To Hon. George W. Atkinson, President of the State Geological and Economic Survey Commission:

The following summary of the work accomplished by the State Geological and Economic Survey during the past year is hereby submitted:

Under the authority conferred by the Commission when it appointed me Superintendent of the Survey, I proceeded to organize the same, after formal acceptance of the office on my return from Russia, in November, 1897.

Owing to the limited resources granted by the Act establishing the Survey, it became a serious problem as to how the immediate work (establishing and properly marking the true meridians in every county) required by the Act, could be carried into effect and have any funds left for the main purposes of the Survey. In this dilemma, I turned to the United States Geological Survey, and happily secured aid and co-operation from that organization. Through the authority granted by the Commission at the December, 1897, meeting, I concluded a contract with Mr. Charles D. Walcott, Director of the U. S. Geological Survey, under which the true meridians were to be established by that Survey in every county of the State, and all appropriately marked by stone monuments and metal tablets, at a total expenditure of only five hundred dollars ($500), a mere

tithe of the sum it would have cost had the work been done by the West Virginia Survey organization. This sum has already been paid to the National Survey upon properly certified vouchers for field expenses, and I am in receipt of information that the work of locating and marking the meridians has just been completed, the last monuments having been set at New Cumberland, Hancock county, on December 14th, 1898. A full and detailed account of this work, the location of the different monuments, and the variation of the magnetic compass in the several counties of the State will appear in the Petroleum Report of the survey, which will be published in February or March of the coming year.

Prof. S. B. Brown, of the State University, who was appointed Assistant Geologist at the first meeting of the Commission, has about completed the task then assigned him, viz.: a bibliography of all the published reports, maps and other writings concerning the territory covered by West Virginia, not only during its existence as a separate commonwealth, but previously when it was a part of Virginia. This interesting record will find a place in the Coal Report to be published as soon as the Legislature shall have granted the necessary funds.

Prof. R. L. Morris, of the Engineering Department of the University, volunteered to prepare the base for a new map of the State at a very small compensation, and the result of his work is now in the hands of the engravers, A. Hoen & Co., of Baltimore, Md., with whom a contract has been signed for the publication of two thousand copies of the map, upon a scale of ten miles to the inch, folded and enclosed in

manilla envelopes with appropriate description thereon. The contract price for the two thousand copies delivered at the office of the Survey, is three hundred ($300) dollars, and additional copies can be ordered at any time at the rate of fifty ($50) dollars per thousand. This map will show the county lines, cities, towns, postoffices, railroads, and principal streams of the State. The location of the oil and gas pools will also be indicated by appropriate symbols, and the coal deposits (New River, Pocahontas, Kanawha, and Monongahela series), will be shown with separate colors for each series. The topographic base of the map is, of course, quite inaccurate, and must remain so until actual surveys by the Government or State, or both combined, have covered our entire area, but as the State had no map whatever, it was thought desirable to publish one, since even a poor map is better than none. This map is promised for distribution before the end of next month (January).

The Survey was fortunate in being able to secure the services of Mr. John M. Gregg, of Morgantown, West Va., to act as Chief Clerk. Mr. Gregg has had much experience in general clerical work, is a skillful penman, typewriter and bookkeeper, and has now added stenography to his other accomplishments. It is hoped that we may be able to retain his services premanently, but in order to do so his salary will have to be increased to a consic erable extent above the meagre amount ($50 per month), which our limited resources would permit for this year.

Prof. B. H. Hite, the accomplished Chemist of the State Agricultural Experiment Station, at Morgan-

town, has been appointed Chief Chemist of the Survey, at a merely nominal salary ($10 per month) for the present, and he has made many analyses of coal, clay and other minerals during the year.

The State Geologist has spent as much time in the coal and petroleum fields as our resources would permit, gathering data for reports on the same. The report on petroleum and natural gas is nearly ready for the printer, and a contract for its publication will be let within a few days. We have no funds for any kind of illustrations, and from the bids received I estimate that 2,000 copies of the volume, containing about 300 pages, will cost approximately $500.00.

The committee on publication, (Dr. Raymond, the Executive Officer of the Survey, and the State Geologist), has adopted the octavo form as the handiest, most popular and useful size for the principal publications of the Survey.

Several of the States of the Union, including our sister State of Maryland, have inaugurated a system of co-operation in their State Surveys with that of the National organization, the United States Geological Survey. The main purpose of such co-operation is to secure accurate topographic maps of the entire area of a state at small expense to the latter, and many years before such maps will be completed without such assistance and co-operation. That such accurate maps are absolutely essential to the rapid and orderly development of the vast natural resources of our State must be admitted by every intelligent citizen. The several letters addressed to me by the Director of the U. S. Geological Survey, Mr. Charles D. Walcott, will give the details of such pro-

posed co-operation which is the same in terms as that given Maryland, New York, Connecticut, Massachusetts, and other states where such co-operative surveys have proven so popular and beneficial, are herewith filed for your information marked Exhibit "A."

The benefits accruing to any state from the possession of these topographic maps have been recently so well set forth by Prof. A. A. Wright, of Oberlin, Ohio, in an address before the Ohio Academy of Sciences at Columbus, that a copy of the same, together with an explanatory letter from Director Walcott is filed herewith as Exhibit "B," and is made a part of my report. The address reads as follows:

Address of Prof. A. A. Wright.

Members of the Ohio Academy of Sciences:

I have chosen a subject for this occasion which appeals very warmly to my own feelings, and concerning which I have some strong convictions. It enlists my interest as a citizen of this commonwealth, and it seems to me appropriate that it should be brought before this body, which is organized to represent the work and the sentiments of the scientific men of the state.

The proposition which I wish to urge is, that there is need of a topographic survey of Ohio, and that the time has come for having one.

Definition.

By a topographic survey is meant a survey which takes account of the elevations and depressions of the surface of the land, as well as its horizontal extent; and which leads to the construction of an accurate map, with contour lines, at convenient intervals, joining points of real altitude. While ordinary maps only attempt to locate objects according to their latitude and longitude, a topographic map adds to these their elevations above the level of the sea. While ordinary maps deal only with two dimensions of space, the topographic map deals with all three demensions, and in this aspect is complete. We may call ordinary maps "areal" maps, as they show areas only. Such a survey as is proposed would yield a new and independent areal map of far greater accuracy than any which has yet been produced, for only upon such an accurate map would it be worth while to lay down the levels that are run by careful spirit level surveying.

No Accurate Map Exists.

There has never been any such survey in Ohio. The only organization in the state which has ever borne the name of a survey was the Geological Survey, which devoted all its labors directly to geology. While a topographic survey should logically precede a geological survey, and *must* precede the final and most accurate delineation of the geological structure of the state, yet its cost was uncertain, and its urgency seemed less to the legislators than that of the geological problems. The Geological Board did not take the view of the act under which it was organized, that it authorized them to make a topographical map before proceeding to their geological work. The only course that seemed open was the straightforward one of using the best areal maps that were available as a basis for their work—the same common maps that we are using today. I have no criticism to offer upon the course of the Geological Survey; but it is to the point to inquire what our ordinary maps are based upon. I have made inquiry of map publishers both within the state and without the state, as to the existing sources for an accurate map of Ohio. The universal response is that there is nothing satisfactory. The country has been laid out into townships and counties, and there have been disconnected land surveys; but there is nothing in existence to prevent the accumulation of errors or to exert a control by which they may be diminished. It has sometimes transpired, in re-surveying regions as well settled and cultivated as Ohio or New York, that a town, and its environment, is found to have been placed two or three miles from its real position in latitude and longitude. The map makers say that they put together these limited and unco-ordinated surveys and then use their best judgment in reconciling the discrepancies. So it is the "best judgment" of a man in an office in Chicago that gives our maps their finishing touches, instead of an actual measurement of things as they exist. It is true that there is a chain of most accurate triangles along the shore of Lake Erie, made by the Lake Survey, and marked by permanent monuments. But these have been used, so far, only in making an accurate map of the shore line. Also in the northern part of our coal area and along the Ohio river, some points have been fixed and some elevations marked by the United States Coast and Geodetic Survey. We have thus the beginning of a primary triangulation of the state. What is needed is that these should be extended and applied until we have a map which can be used with confidence, and which will respond to the severest tests that can be put upon it.

Value of Contour Lines.

If now, upon *such* an areal map, the elevations and contour lines could be superposed, there would be added to its value an entire realm of facts which are at present unknown and unrealized by the ordinary citizen. If the scale of the maps were such as to permit the country roads and streams to be designated, as it ought to be, then they would lend them-

selves to a thousand uses of our every day life. At a glance one could locate the steeper slopes and the level stretches. The traveler, whether on foot or on wheel, can know the ups and downs of his journey beforehand. The land buyer can bring to book the descriptions of the land seller, seeing for himself what is upland and what is river-bottom, delineated by an authority that is entirely impartial. The engineer can lay out the preliminary profile of his turnpike or electric railway at his office desk, being sure of the correctness of the large points of control; city engineers can calculate the water supply that is tributary to their towns, can know at what levels it can be impounded, and learn by inspection the most economical location of dams, reservoirs, and pumping stations. The feasibility of projected ship-canals and the comparative merits of different routes can be in great measure settled, without expense. The manufacturer, the miller, the miner, the contractor, can know beforehand the best location for his factory, his mill, his shops and his headquarters. Eventually the geological outcrops can be transferred to the same map, in a scheme of colors, the geology explaining the topography and the topography suggesting the geology. Then the sheets will be bearing something like the load of correct information concerning the surface of the state that should be demanded and furnished by an intelligent commonwealth.

Scientific Uses of the Maps.

But these considerations are largely pecuniary. There are others that are scientific, intellectual, and educational, and which will be more highly valued by the thinking citizens of the State. The naturalist has a sore need of topographic maps in all his endeavors to explain the geographical distribution of plants and of animals. In his field excursions, as a mere guide for his trips, they make all the difference between high satisfaction and regret that he had not a better map; while in explaining and recording the distribution of plants and animals, the topography is a factor which injects itself into his problems at every turn. The geologist who is endeavoring to unwind the history of the preglacial drainage of the State and its relations to modern drainage, has at present to map his own topography; and he has nothing to suggest localities where evidence on critical points might be obtained. Unless he is fortunate enough to see the topography of a locality with his own eyes, he cannot know whether there is any problem deserving study at that point or not. In contrast with this we see Professor Davis, of Cambridge, taking the elaborate maps of France and Germany, and, in his laboratory, writing with confidence of the episodes in the history of the Meuse and Mosel rivers, leaving scarcely a word or an opinion to be altered when the place is subsequently visited in person. The physicist and the meteorologist are in equal need of a knowledge of altitudes, that they may interpret aright the pressure of the atmosphere and its ever varying phenomena. Indeed, one cannot foresee all the benefits that would arise from the survey proposed, for every step forward in *exact science* is sure to open up,

and form a basis, for, unexpected advances in related lines. Our duty is to push forward in faith, being sure that our horizon will be broader from the new position attained.

Triumph Over Nature.

As a matter of mere intellectual triumph over nature, the utility of this survey may be urged. Ohio has been settled for over a hundred years, and has become one of the most important commonwealths in the Union. Its interests are diversified. It has enjoyed general prosperity, and in education, in the support of public institutions, and in intelligent appreciation of the best things, it has an honorable standing. But is it not high time that an intelligent people should construct for themselves, and thus be able to contribute to the world a consistent and complete representation, in three dimensions, of that portion of the earth's surface with which their fortunes are inevitably linked? To subdue, to cultivate, to comprehend, to prepare for man's uses with the utmost refinement this surface which is the most persistent and conspicuous element in the environment of man, should be a task, in the accomplishment of which a worthy sense of satisfaction and triumph may well be indulged.

Shall Ohio Be Behind?

Moreover, if we are to keep our place in the ranks of the more enlightened states and countries, we cannot delay long. Several of our Eastern States, including Massachusetts, Connecticut, Rhode Island, and New Jersey, have their topographic maps entirely completed, and are reaping the practical and intellectual benefits of their enterprise. Several others, like New York, Missouri, and California, have their maps partly completed, while considerable areas of Western territory have been mapped by the surveying forces of the National Government. A number of our neighboring states to the westward are maturing their plans for such a survey, and ere long Ohio, if she does not move, will seem to be a laggard upon this subject. The European nations have long ago provided themselves with surveys of great elaborateness of detail, by government authority. We shall not be leading, but rather following, in our appreciation of the advantages of a correct and complete map—if we enter upon this task at once.

Educational Aspect.

In one other aspect, the utility of such a map may be urged, and urged with greater force than it could be at any previous epoch. This is the educational aspect. Within a few years past a new vitality has been infused into the subject of *geography* in all its branches, from the simple forms first given to children, up through physical geography and physiography to dynamic geology, and the origin of surface forms. The "New Geography" differs from the old in looking at surface features—not as dead and fixed forms, but as passing through the stages of growth, maturity, and old age. Every mountain, plain, and river-valley carries

in its structure the record of its birth, decline, and perhaps rejuvenation; always changing, never resting, always pursuing the steps of its evolution, slow though they be. This newer conception of the science, together with the better methods of teaching, which send both teacher and pupil directly to nature, create a necesssty for a kind of maps and of literature which. do not as yet exist. As the study begins with home geography, every school district must work out a geography for itself which will be different from that of any other district. In order to do this, there is need of certain standards and starting points which a survey of the State would furnish, and there is need of a varied supply of topographic forms, already mapped and accessible for study, both to teacher and pupil. These must be supplied by the sheets covering other portions of the State or of other states and countries.

The ability to read and interpret a topographic map is almost as foreign to the people of average education today, as is the ability to understand a common map among those who are wholly uneducated. Considerable practice is necessary before one can appreciate comparative altitudes, or imagine in one's mind the profile of a slope, from the contour lines of a map. It is like the study of solid geometry and it requires the command of the imagination in a constructive process of some complexity, but still not difficult. The ability to read such a map is of great advantage to any mind. To represent topography in solid models or raised maps is an expensive and tedious task. The cheapest and most available way of presenting topography is upon maps with contour lines; and it is not too much to say that every school boy should have practice in the use of such maps.

Plans For a Survey.

But however desirable a topographic survey may seem to us, we shall not be discussing the subject to any purpose until some practical plan is proposed of making the survey, and its cost considered.

Three different methods of procedure may be mentioned, in which the cost would vary with the method pursued. The first method suggested would be that of utilizing the various railroad profiles that cross the State in every direction, as a basis for altitudes, and working from these with the aneroid barometer for the intermediate country. The contour lines for altitude could thus be obtained. For the areal map, upon which these lines should be laid down, we might use the best existing maps of the State and of the separate counties, or the best that could be made by new compilations, without resorting to a triangulation survey. This would undoubtedly be the least expensive system that could be devised. It is the method resorted to by the State of Illinois shortly prior to the Columbian Exposition, to obtain the data for a raised map or plaster model of the State for exhibition in 1893. It was estimated by Professor Rolfe, who superintended the work, that the errors in the elevations would rarely if ever exceed ten feet.

A second method would be for the State to co-operate with the topographic division of the United States Geological Survey, of Washington, the work being done by their experienced engineers. Upon this plan there would be a primary triangulation survey, covering the entire State with large triangles. The smaller areas would be worked out with the plane table and other processes, the result being an entirely new and independent areal map of the State as it is. The hydrographic division would give especial attention to the correct representation of the streams and drainage of the State, while a third division would give the elevations, these being taken entirely by surveyor's level, and nothing being left to the shifting barometer. The maps resulting from this survey would be in harmony with a plan already well inaugurated by the United States survey, of eventually covering the whole country with a good topographic survey preparatory to a complete geological survey. Over 600 topographic sheets have already been issued, each sheet covering a quarter of a degree square, or some multiple of this area. The United States survey will place its topographers in those States where co-operation is offered, they themselves bearing *half* the expense of the survey, while the State contributes the other half.

This kind of a survey would be vastly more accurate and valuable than the railroad and barometer survey, and would cost a good deal more. But it would cost the State only half the actual expense of the work.

A third method would be to organize a State topographical survey, for the purpose of making a map, of such a degree of elaborateness as might be agreed upon. It ought to be nothiug less than a trigonometric and spirit level survey, resulting in an entirely new and authoritative areal map as well as altitude map. It might be made upon a larger scale and with more detail than the one which the geological survey would propose, but *their* proposal would be, such a great advance upon anything now in existence that the State would not be likely to support anything more elaborate. The comparative merits of the second and third methods may be judged by proposing that they should both undertake to produce the same map. Which of the two could produce the map at the least expense? There is at present no bureau under the State government which is equipped for such an undertaking. It would be necessary therefore to organize one anew if the State should undertake the work. New instruments, offices and equipments of every kind would have to be provided, a corps of engineers appointed, organized and trained, and all the preliminary questions as to methods of procedure discussed and settled, before the beginning of efficient work. The United States engineers, on the other hand, are already in efficient working order. Considering these facts, it has been estimated by careful experts that it would cost the State of Ohio three times as much to produce a map as it would the United States Geological Survey. And since the National Survey would be willing to bear half the actual expense, it wonld cost the State only one-sixth as much, to co-operate, as to proceed independently.

Of the three methods, therefore. there can be no question that the adoption of the second would give the best results for the money expended ; and

it would seem that all consideration of the subject of a topographic map ought to be concentrated upon this one plan.

Results in Other States.

The results of State co-operation with the United States Survey have been very satisfactory in the States where it has been tried. New Jersey was the first State to complete her work in this manner, and it has already become classic ground in the advance study of topographic forms and their development. Every school district in the State has been supplied with a full set of the maps, both topographic and geologic. In Massachusetts, Professor Shaler says the educational argument was the consideration that really carried the day, though other arguments were numerous. The points gained, he says, by co-operation were that "we got a better map and got it sooner than we could possibly have obtained it in any other way."

In Connecticut, Professor Brewer, of Yale, says: "The map has been *very* satisfactory; is used for a great variety of interests. The Geological Survey did its work well, *very* well as a whole, although the sheets are of unequal excellence." The expenditure was somewhat less per square mile in Connecticut than in Massachusetts.

Dr. Walcott, the Director of the United States Survey, has kindly written out in some detail, suggestions and estimates for a survey of Ohio, and the course that matters would be likely to take can best be learned by noting his statements. He says:

Dr. Walcott's Statement.

"In view of the highly cultivated condition of the State and the destiny of its population, I am of the opinion that, if a fixed scale be deemed best for the whole State, that scale be the same as is or was employed in mapping New York, Pennsylvania, and the New England States, viz: approximating one mile to the inch, with a contour interval of twenty feet. Such a scale will be decidedly the most satisfactory from a topographic point of view, and the resulting map will be much more satisfactory for engineering purposes and as a general base and guide map for all purposes. It is sufficiently large to admit of the representation of all the numerous cultural features which will have to be shown. If, on the other hand, it is desired to economize, a scale of two miles to the inch may be employed, but the relief is so slight that the contour intervals should still be twenty feet. To make such a map will cost but little less than to make the former, because the chief cost will be incident to obtaining the vertical relief contours; yet a saving of about $2 per square mile may be made by employing this scale. In this event it would still be necessary, in my opinion, to map the atlas sheets containing the larger cities, those say containing over 50,000 inhabitants, on the larger scale, employing the smaller and cheaper scale for the remainder of the area.

"The State of Ohio contains 40,760 square miles, most of which is well inhabited and fairly clear of timber, and well cut up with roads, so that its

survey will not be especially difficult. Practically none of this area has yet been mapped, nor is there in existence any map material other than elevations along railway and canal lines which will aid in the preparation of the topographic maps.

"The survey of 40,000 square miles on a scale of one mile to the inch, with twenty-foot contours, and including the running of the necessary primary level lines, will cost between $8 and $9 per square mile for the whole State, provided money be forthcoming in sufficiently large amounts to enable the work to be conducted in the most economic manner, say at a total rate of expenditure of $20,000 per annum, or a total maximum cost for topography of $360,000. In addition the prosecution of the triangulation over this area will cost at least $1 per mile, perhaps a little more. Say for this $40,000, provided funds for this work be forthcoming at the rate of not less than $5,000 per annum. Accordingly the total cost of mapping the State, including triangulation, will average $10 per square mile and amount to $400,000.

"The State of Massachusetts was mapped at an average cost of $12 per square mile; Connecticut at about $10.50 per square mile. This organization has agreed to map New York State for $10 per square mile. The work has progressed at that rate for the past four or five years, but owing to the introduction of more careful spirit level work it will cost henceforth a little more. The State of Ohio could probably be mapped for $7 per square mile, but owing to the total lack of primary triangulation, which was almost complete throughout the areas of New York and New England, and owing to the necessity of doing better spirit level work than was formerly done, I am of the opinion that the figures above given will be very close to the truth.

"Estimating the total cost of the survey to be $400,000 the State would have to appropriate $200,000. If this sum were appropriated most advantageously, it would be at the rate of $25,000 per annum, or $50,000 per legislative session. This organization would appropriate a like amount, the total annual expenditure being $50,000. At a rate of survey corresponding with this, eight years would be required for the completion of the mapping of the State. Lesser biennial appropriations would prolong the time of survey proportionately and increase the cost a little.

"The map would cost the State $5 per square mile, and for this relatively small outlay the State will receive an accurate topographic map of its entire area on a scale and at a contour interval sufficiently large to represent all its cultural and topographic features. This map will show the surface relief for every twenty feet of vertical height. It will show the direction and position of all streams, ponds, lakes and swamps. It will show all roads, public and private, and all houses in their true position and in such a manner as to indicate their relation, not only to each other, but to the drainage system and to the hills. valleys and slopes of the State. It will also show the outlines and extent of all wooden areas. As permanent monuments of this survey, there will also be left all over the country so mapped, copper bolts or plugs, marking exactly the geodetic position of primary triangula-

tion points. These will be at distances apart not greater than twenty miles, and will serve as initial points for the conduct of all future surveys of every kind. There will be left copper bolts or tablets at points six miles apart throughout the entire State, marking the elevation of these points above sea level to the smallest fraction of a foot. These will serve as datum points for the prosecution of further spirit level work for all engineering investigations and for such public works as canals and municipal water supply, or for railways or other private or semi-private surveys.

"As acknowledged by the State engineer of New York, and by other authorities who have co-operated with this survey, their states could not, and I am confident that Ohio could not, duplicate such a survey for two or three times the cost at which it can be prosecuted by the well organized and well disciplined force of the Geological Survey. It would probably cost the State to map its territory *alone* $30 per square mile, against $5 by the other plan. Moreover, the State will have these maps engraved by the government (a most important item) *free of cost*, as they will be engraved by the Geological Survey. Furthermore, when these maps are completed they will be put to the primary use designed by the government, namely, as base maps upon which to represent surface and economic geology. The State will thus come into the possession of a set of *geologic maps* at no further cost to it than one-half the cost of the topographic survey. Still another benefit which will accrue to the State by having this survey made in co-operation with the Geological Survey is that a great mass of information will be gathered in the course of map-making relative to the drainage and water supply of various streams, both through the topographic and hydrographic branches of this survey; and this information will be of inestimable value to all who are engaged in the utilization of the water resources of the State, either for domestic consumption, the supply of canals, or the production of power for water supplies. The State of Maine considers this feature of the topographic survey alone as warranting the expenditure; as does also the State of New York, in connection with water supplies for its canals, and in making compensation to mill owners for water diverted from them for state uses.

"I would suggest that bills be introduced biennially in the Legislature, similar to those passed by the State of New York; and carrying sufficient appropriation to continue the work from one session of the State Legislature to the next: This should be expended either through a commission, as in Massachusetts and Connecticut, called a State Topographic Survey Commission, or better still, be expended through one individual or office, as in the case of New York, which is represented by the State engineer and surveyor. The State representative is generally empowered to examine the reports, accounts, and field work in connection with the Geological Survey, and if at any time he finds the work is not being done in accordance with the agreement, he may terminate it."

Classes Benefited.

In addition to these details concerning a plan of survey, the Director has

answered some questions as to what classes of persons have been benefited by the maps and have sought them for use. He says:

"From Massachusetts we have received numerous appeals from educational institutions requesting maps for school purposes. Engineers and projectors of public enterprises and those interested in hydrography and sanitation apply for the maps to study topography, water supply and drainage. Those having large realty interests also endeavor to obtain the maps to locate thereon their landed estates. Of recent years a constant and growing demand has been made by bicyclers. The requests originating from Rhode Island are of a general nature, but have not left an impression of any special or distinctive characteristic.

"From Connecticut we receive letters similar to those received from Massachusetts, with the addition of that influence caused by the suburban interest of New York City.

In New Jersey the requests are varied, railroad and farming sharing equal portions of the interest of the applicants. These states are, however, all included in a thickly settled region of advanced development. But from other states where the best existing ordinary maps are few, being compilations from various sources and records, there originates another class of applications. The home seeker, mining prospector, railroad and irrigation engineers, investment companies and all of the many followings of commercial life are numbered among those who appeal to the government for maps."

The sheets composing the map of Ohio would doubtless be issued in uniformity with the sheets covering New England, each being about 17 by 21 inches in size, and printed in three colors, the streams and bodies of water in blue, the contour lines of elevation in brown, and the works of man, or "cultural" portion, such as roads, houses, towns and political divisions, in black. Each sheet would have a name from its principal town, as the "Columbus" sheet, the "Lorain" sheet, etc. The sheets could be kept separate in a portfolio, for use singly, or they could be bound into a thin atlas.

These details of information, furnished by the Director, place the project before us in a very definite form. The nature, the quality and the expense of the work can be certainly known before hand.

Action at the Present Time.

The question of inaugrating topographical work in Ohio has been exploited before, without success. Twenty-five and thirty years ago it was a frequent subject of appeal by Col. Cyrus Whittlesey, of Cleveland, in connection with the development of the coal seams of the nortwestern portion of the State. Later, in connection with the State geological survey, the needs of such a survey were urged, but its claims seemed not to be appreciated by the Legislature. During these years of waiting, however, the National survey has been developing remarkable strength and acquiring most valuable experience, both by its tentative and by its completed work.

And now the opportunity is afforded us, through their co-operation, of obtaining a topographic map, executed upon such a scale and plan, reaching such a degree of quality, and upon such a scale of expenditure as has commended itself to the judgment and experience of the most important States lying east of us. Is there any wiser, more economical, more business-like way of obtaining such a survey? The entire cost of $200,000 is no more than has been repeatedly and properly expended in the erection of a single building for some of our public State institutions. It is less than one-third of the amount which was recently given by Mr. Rockefeller for extending and beautifying the park system of Cleveland, a city in which he had formerly resided.

The benefits of a topographic survey would be distributed to every part of the State, to every square mile of its area and to every citizen within its limits, ministering to his physical and intellectual advantage, and prompting him to enterprises of public importance. To undertake it is a duty which all owe to all, and the Legislature in providing for it would merely be recognizing the obligation which the commonwealth owes to itself and to the world.

The question as to how the citizens of the State would share in this work if it is to be undertaken by the U. S. Geological Survey, is specifically answered by the following statements from Mr. Herbert M. Wilson, Topographer of the U. S. Geological Survey:

"According to the plan pursued in other States, only a limited number of men will be sent out from Washington, the larger number being employed in the region where the work is in progress. The work will be in charge of from ten to a dozen of the experinced topographers permanently employed by the United States, acting as chiefs of parties. All other surveyors, as level men, transit men, etc., together with rod men, assistants and helpers, will be employed in accordance with the regulations of the Department of the Interior, in the locality in which the work is being done. Thus the local surveyors and engineers of the State of West Virginia will find employment, and the benefits will inure to them both in compensation for services rendered and in possession of the fixed monuments which

are established by the surveying parties.

"The salaries of all the employes will be paid by the federal government, and certain portions of these sums will naturally be expended in the regions where work is going on. The money which is appropriated by the State will go in payment of the subsistence of the parties, and in supplies. It will thus be going to hotel keepers, to dealers in provisions, to hardware men, to livery men or others for the hire of animals, and the like. Thus all the money appropriated by the State, and more than half of the similar sum appropriated by the federal government, will be expended within the State."

That accurate maps are absolutely essential to the proper delineation, and description of a State's mineral and other resources, admits of no controversy, and we now have opportunity of receiving these at a very small annual cost, not exceeding $10,000 per annum to the State through a period of only ten to twelve years. It is the part of wisdom to avail ourselves of this proffer of Governmental aid at once, since most of the counties of the State have no official maps of any kind, and those extant are so inaccurate and out of date as to be little better than worthless.

The following estimate of annual appropriations necessary to carry out the requirements of the Act establishing the State Survey is based upon the expectation that co-operation with the National organization will be inaugurated by the coming session of the Legislature :

For co-operation with the U. S. Geological Survey in the preparation of a complete topographic map of the State..... $10,000
For salaries of the State Geologist and three assistants 4,000
For salary of Chief Draughtsman and Topographer and two assistant

topographers	2,500
For salary of Chief Chemist	300
For salary of Assistant Chemist	600
For salary of Biologist	300
For salary of Botanist	300
For salary of Entomologist	300
For salary of Chief Clerk	1,200
For salary of Assistant Clerk	500
For engraving, printing and binding	5,000
For field, office, traveling and incidental expenses	5,000
Total	$30,000

The above estimate is based upon the most economical plan of securing a complete topographic map of the State, within a period of twelve years, by co-operation with the National Survey, and at the same time completing the study, classification, description and publication of all the natural resources, and other data contemplated by the Act under which the Survey was organized. The only item of this estimate which could be subject to any material variation, and not impair the efficiency of the Survey, is the first one. That item can be either increased or diminished, and its only effect will be to change the time for completion of the topographic map. The estimate of Director Walcott, of the U. S. Geological Survey, based upon actual cost in several States, is $5.00 per square mile, as the price each State must pay on the present plan of co-operation for a completed map on the scale of one mile to the inch. Since there are 24,000 square miles in our area, the entire cost to the State of West Virginia will be $120,000, and this can be distributed through 20 years, 12 years (as I have suggested,) 10 years, or even 5 years, by simply making the appropriations for each year's co-operation either smaller or larger. For every dollar the State puts into the field work on the map, the Government will not only put another dollar, but pay all salaries of

the surveying corps, and in addition bear the entire expense of engraving the maps in the highest style of art, upon plates which are to be preserved forever. Should it be desirable to have this work completed in six years instead of twelve, then the appropriation for co-operation must be $20,000 annually instead of $10,000 as above recommended.

Should this plan of co-operation submitted for your consideration be presented to the Legislature, and adopted by that body substantially as here recommended, the State Geologist would be enabled to carry into execution within the twelve (12) years contemplated, all the requirements of the original Act, and in addition to the reports on special subjects, would be enabled to publish a volume on each county of the State with a full description of its geology, and natural resources of every kind, together with a correct topographic map of the same. These detailed reports prepared by experts, and under the authority of the State, would be of great and lasting value to the several counties, as well as to the State at large, since a summary of the detailed county work would also be published covering the State as a whole, and correlating and classifying the results of all geological and other investigations.

The detailed financial statement which has been submitted may be summarized and supplemented by estimated expenditures to April 1, 1899, as follows :

Expenditures.

For locating and setting meridian mounments, U. S. Geological Survey, paid in full	$499.96
Field and traveling expenses	254.81
Office expenses, including postage, stationery, telephone, expressage, etc.	184.35
Salaries to December 1st, 1898	2,953.50
Salaries to be paid to April 1st, 1899	990.04

Expenses of three meetings of Survey Commission	124.00
Expenses of Charleston meeting of Commission	74.78
Contract with A. Hoen & Co., Baltimore, Md., for publication of 2,000 copies of State map, to be paid	300.00
Cost of publication of 2,000 copies of Report on Petroleum, True Meridian locations, etc., estimated	500.00
Office and incidental expenses to April 1, 1899, estimated	75.00
Total	$5,956.44
Appropriations for the Survey	$6,000.00
Total expenses as above paid and estimated to April 1, 1899	5,956.44
Estimated balance, April 1, 1899	$43.56

Notwithstanding the law upon the statute books requiring the several gas and oil companies operating in the State to shut in all gas wells and prevent the waste of this precious fuel, there is yet an enormous waste going on in several counties of the State. There is a penalty attached for non-compliance with the law, but so far it has never been enforced, and is not likely to be until some one person is charged with the execution of the statute. The State of Indiana has found It necessary to have a special officer, called the State Gas Inspector, whose duty it is to see that the law is enforced on the subject of prevention of natural gas waste, and the proper penalty exacted for its violation. I think this is the best plan of preventing the evil complained of, and that the attention of the Legislature should be called to the matter.

In one county alone (Wetzel) it is estimated that the waste of gas, counting that which escapes with the oil production, and which the present statute does not therefore prohibit, amounts to much more than 100,000,000 cubic feet daily. When we remember that this is equivalent in heating power to more than 100,000 bushels of coal, the loss to the resources of the State be-

comes simply appalling, and calls loudly for some effective remedy.

All of which is respectfully submitted.

I. C. WHITE,
State Geologist.

Morgantown, December 20th, 1898.

After a thorough discussion of the above report of the State Geologist, the Commission unanimously approved the plan proposed by him for the future work of the Survey. The proposed co-operation with the United States Geological Survey is especially approved, as well as all the other features recommended by Dr. White for the completion of the State Geological Survey, so essential to the future prosperity of all the people of the State. The Commission also went carefully over the several items in the estimates submitted by the State Geologist and it unanimously endorses the same, and asks the Legislature to appropriate the full amount of thirty thousand dollars per annum for the years 1899 and 1900. The State Geologist was authorized to contract with the lowest responsible bidder for the immediate publication of his report upon petroleum and the meridian locations in the several counties.

The Commission then adjourned to meet at the call of the President.

GEORGE W. ATKINSON,
President.

JEROME H. RAYMOND,
Secretary.

Part II.

LEVELS ABOVE TIDE.

The following lists of elevations above tide of the several stations on all the principal railroads of the State, have been kindly furnished by the officers of the same. When not otherwise stated the elevation is the top of the rail in front of the center of the station building:

Baltimore and Ohio Railroad.

OFFICE OF THE CHIEF ENGINEER,
November 30, 1898.

DR. I. C. WHITE,
State Geologist,

DEAR SIR:—Replying to your favor of the 22nd inst., I beg to attach list giving distances and elevations of various stations along our line in West Virginia.

We have no profiles of short Branches on the Second or G. & B. Division, and, therefore, cannot give the information on these.

Yours very truly,
W. T. MANNING,
Chief Engineer.

Main Line.

Distances from Camden Station, Baltimore.	STATIONS.	State.	County.	Elevation Above Tide.
75.6	Brunswick,	Md.	Frederick.	.....
78.0	Knoxville,	.....	....	.....
78.5	Weverton,	.....	Washington.	.....
80.4	Sandy Hook,	.....	....	.....
81.0	Mountain Siding,	.....	....	.....
81.4	Harper's Ferry,	W. Va.	Jefferson	280
82.4	Island Park,	.....	....	300
83.2	Peacher's Mill,	.....	....	335
84.2	Rau Mining & M'fg Co.	.....	....	.....
84.8	Engle,	.....	....	388
87.9	Duffields,	.....	....	508
88.8	Shenandoah Junction,	.....	....	536
89.2	Hobbs,	.....	... .	.....
	Summit,	.....	... .	600
92.1	Stone Crusher Siding,	.....	....	.....
92.3	Kerneysville,	.....	Berkeley.	550
95.2	Vanclevesville,	.....	....	477
97.0	Opequon,	.....	... .	400
97.8	Flagg,	.....	... .	.....
100.	Martinsburg,	.....	.. ..	445
101.0	Baker's Stone Crusher,	.....	... .	475
102.1	Fawver,	.....	... .	.....
103.5	Tabb,	.....	....	535
104.7	Wilson,	.....	....	533
107.4	North Mountain,	.....	... .	540
107.8	Helper's Switch,	.....	....	.....
112.2	Cherry Run CoalChute,	.....	... .	.....
113.4	Cherry Run,	.....	Morgan.	410
115.5	Miller,	.....	... .	404
117.3	Sleepy Creek,	.....	... .	412
121.8	C. E. Jones,	.....	... .	.....
122.8	Hancock,	.....	....	.....
123.8	Sand Siding,	.....	... .	.....
125.8	Round Top,	.....	....	433
128.4	Sir John's Run,	.....	....	436
130.5	Henry's Siding,	.....	... .	.....
132.4	Great Cacapon,	.....	... .	437
133.3	Woodmont,	.....	.. ..	453
135.7	Lineburg,	.....	....	450
138.7	Orleans Road,	.....	....	501
139.5	Rockwell's Run,	.....	... .	.....
141.	Doe Gully,	.....	....	550
143.3	Hansrote,	.....	... .	.....
145.6	Baird,	.....	....	498
148.9	Magnolia,	.....	... .	495
153.8	Paw Paw,	.....	....	530
156.7	Little Cacapon,	.....	Hampshire.	533
158.6	Okonoko,	.....	....	535
161.4	French,	.....	....	540
164.1	Green Spring,	.....	....	550
168.4	Dan's Run,	.....	Mineral.	563
170.9	Patterson's Creek,	.....	....	568
172.5	North Branch,	Md.	Alleghany.	620

Main Lines.—Continued.

177.0	Steel Works,	Md.	Alleghany.	.....
177.2	Glass Works,	.....	....	.....
178.0	Cumberland,	.....	....	639
181.	Three Mile Water St'n,	.....	....	627
181.3	Robert,	.....	....	.....
183.5	Cedar Cliff,	.....	....	642
185.0	Brady,	.....	....	657
187.3	New Potomac Cement Works,	.....	....	.....
		.....	....	.....
187.5	McKenzie,	.....	....	.....
188.1	Potomac,	.....	....	670
190.0	Lowndes,	.....	....	.....
190.8	Cresap,	.....	....	692
191.5	Rawlings,	.....	....	698
195.0	Black Oak,	.....	....	736
197.0	Dawson,	.....	... .	750
199.2	21st Bridge,	.....	....	786
201.5	Keyser,	W. Va.	Mineral.	805
206.5	Piedmont,	.....	....	910
207.7	W. Va. Central Junc'n,	.....	....	.....
208.5	Bloomington,	Md.	Garrett.	1020
209.	Black Bear,	.....	....	.....
211.8	36 W. S.,	.....	....	1385
212.2	Crabtree,	.....	....	.....
214.3	Frankville,	.....	....	1696
217.9	37 W. S.,	.....	....	.....
219.4	Swanton,	.....	....	2282
222.3	Wilson,	.....	....	.....
223.3	Altamont,	.....	....	2620
226.0	Deer Park,	.....	....	2490
226.3	Deer Park Hotel,	.....	....	.....
228.2	Lake Youghiogheny,	.....	... .	.....
229.4	Mountain Lake Park,	.....	....	2396
231.2	McGowan Switch,	.....	.. ..	.....
231.7	Oakland, W. S.,	.....	....	.....
232.0	Oakland,	.....	....	2374
233.4	Stone Crusher,	.....	... .	.....
234.0	Offutt,	.....	....	2370
235.0	Skipnish Junction,	.....	... .	.....
237.6	Hutton,	.....	....	2486
238.3	Corinth,	W. Va.	Preston.	2430
239.6	Holmes,	.....	....	.....
240.4	Hazen,	.....	....	2500
240.6	Rinard,	.....	....	.....
241.6	Riggs,	.....	... .	.....
242.1	Terra Alta,	.....	....	2550
247.3	Rodemer,	.....	... .	.....
250.6	Amblersb'g, Bradshaw,	.....	... .	1585
253.9	Stoer Mill Siding,	.....	... .	.....
254.4	Rowlesburg,	.....	....	1394
259.0	Anderson,	.....	... .	1855
260.7	Tunnelton,	.....	....	1823
261.8	West End,	.....	....	.....
263.1	Smoot,	.....	....	.....
263.7	Austen,	.....	... .	1575
267.0	Orr,	.....	....	.....
267.4	Newburg,	.....	... .	1218

Main Lines.—Continued.

268.6	Independence,	W. Va.	Preston.	1155
270.0	Hardman,	.....	Taylor,	.....
271.7	Irontown,	.....	.....	1073
274.7	Thornton,	.....	.....	1040
276.0	Painter Siding,	.....	.....	.....
280.2	Grafton,	.....	.....	988
281.8	Fetterman,	.....	.....	986
286.1	Bush,	.....	.....	.....
287.9	Valley Falls,	.....	Marion.	971
289.5	Nuzum,	....	.....	938
292.6	Sand Switch,	.....	.....	.....
294.4	Colfax,	.....	.....	.....
297.4	Benton Ferry,	.....	.....	885
298.4	King,	.....	.....	.....
300.6	Palatine Mines,	.....	.....	.....
301.0	Gaston Junction,	.....	.....	885
301.7	New York Siding,	.....	.....	.....
302.1	Fairmont,	.....	.....	879
303.0	F., M. & P. Junction,	.....	.....	.....
303.5	Central Mines,	.....	.....	.....
303.8	Barnesville,	.....	.....	873
304.8	West Fairmont Shaft,	.....	.....	.....
307.4	Barracksville,	.....	.....	903
307.7	West Siding,	.....	.....	.....
312.8	Farmington,	.....	.....	928
316.3	Downs,	.....	.....	.....
320.0	Mannington,	.....	.....	969
324.3	Metz,	.....	.....	.....
325.7	Wilfong,	.....	.....	.....
327.2	Glover's Gap,	.....	.....	1050
328.0	Wells Siding,	.....	.....	.....
331.8	Burton,	.....	Wetzel.	1070
333.5	Hundred,	.....	.....	.....
336.2	Quarry Switch,	.....	.....	.....
338.0	Littleton,	.....	.....	974
339.0	Jones' Siding,	.....	.....	.....
340.0	Floyd Siding,	.....	Marshall.	.....
341.2	Board Tree,	.....	.....	1105
344.3	Bellton,	.....	.....	888
346.4	Garrett Siding,	.....	.....	.....
348.2	Cogley,	.....	.....	.....
351.8	Cameron,	.....	.....	1048
353.8	Loudenville,	.....	.....	.....
356.3	Easton,	.....	.....	970
362.0	Roseby Rock,	.....	.....	775
363.6	Gatts,	.....	.....	.....
366.4	Gatts No. 2,	.....	.....	.....
368.6	Moundsville,	.....	.....	642
369.4	Camp Ground Junct'n,	.....	.....	.....
370.0	Moundsville Coal Shaft,	.....	.....	.....
370.0	Moundsville Mining & Manufacturing Co.,	.....	.....	.....
370.1	Moundsville Glass Works,	.....	.....	.....
370.6	Moundsville Brick Works,	.....	.....	.....
369.7	Hart,	.....	.....	.....

Main Lines.—Continued.

370.9	Glendale,	W. Va.	Marshall.	.....
373.4	Riverview,	.....	.....	.....
374.3	McMechen,	.....	.....	.....
375.0	Benwood Junction,	.....	.....	.....
376.1	Bellaire,	Ohio.	Belmont.	.....
375.8	Benwood,	W. Va.	Marshall.	650
376.5	Nolan,	.....	.....	.....
376.5	Riverside Furnace,	.....	.....	.....
377.3	Boggs Run,	.....	.....	.....
377.3	No. 17 Switch,	.....	.....	.....
379.8	Wheeling,	.....	Ohio.	647

Parkersburg Branch—B. & O. R. R.

280.2	Grafton,	W. Va.	Taylor.	988
282.3	Webster,	.....	.....	1005
286.4	Foster,	.....	.....	1110
287.2	McCartney Switch,	.....	.....	.....
287.7	Simpson,	.....	.....	1086
288.2	Giles,	.....	.....	.....
288.7	Gramm Switch,	.....	.....	.....
290.0	Flemington,	.....	.....	1015
292.3	Tyrconnell,	.....	Harrison.	989
297.6	Bridgeport,	.....	.....	971
300.7	Despard Mines,	.....	.....	.....
.....	Harrison Co. Mines,	.....	.....	.....
301.9	Pinnickinick Mines,	.....	.....	.....
.....	Clarksburg, old depot,	.....	.....	1030
302.5	Clarksburg, new depot,	.....	.....	1000
303.1	W. Va. & Pitts., and	.....	.....	.....
.....	Monongahela River	.....	.....	.....
.....	R. R. Junction,	.....	.....	.....
304.1	Adamston,	.....	.....	952
306.2	Wilsonburg,	.....	.....	973
309.0	Dolan Mines,	.....	.....	.....
309.8	Wolf Summit,	.....	.....	1120
314.1	Cherry Camp,	.....	.....	1016
316.0	Salem,	.....	.....	1034
321.7	Long Run,	.....	Doddridge.	842
324.1	Morgansville,	.....	.....	800
326.1	Middle Island,	.....	.....	.....
326.9	Smithton,	.....	.....	784
329.2	Ringer Switch,	.....	.....	.....
330.0	West Union,	....	.....	809
332.1	Ruly Siding,	.....	.....	.....
333.0	Central,	.....	.....	802
336.3	Duckworth,	.....	.....	937
337.1	Greenwood,	.....	.....	860
338.7	Toll Gate,	.....	.....	785
342.1	Pennsboro,	.....	Ritchie.	848
347.4	Ellenboro,	....	.....	771
352.2	Cornwallis,	.....	.....	675
353.0	Reitz Siding,	.....	.....	.....
353.9	Fewsmith Switch,	.....	.....	.....
354.9	Cairo,	.....	.....	667
357.2	Silver Run,	.....	.....	794
360.3	McTaggart,	.....	.....	.....

Parkersburg Branch—B. & O. R. R.—Continued.

361.9	Petroleum,	W. Va.	Ritchie.	685
364.1	Volcano,	.....	.....	719
364.9	Eaton,	.....	Wood	763
369.1	Walker,	.....	.....	616
370.1	Textor Siding,	.....	.....	.....
374.2	Kanawha,	.....	.....	599
375.1	Sherwood Switch,	.....	.....	.....
377.2	Davisville,	.....	.....	596
378.1	Ewing,	.....	.....	596
379.2	Jackson,	.....	.....	624
380.1	Stewart,	.....	.....	598
381.2	N. O. C. Co. Tipple,	.....	.....	.....
383.5	Parkersburg,	.....	.....	629
384.9	Belpre,	Ohio.	Washington.	.....

Wheeling & Pittsburg Branch—B. & O. R. R.

0.	Wheeling,	W. Va.	Ohio.	647
2.	Mt. De Chantal,	.....	.....	672
4.	Carbon,	.....	.....	667
9.	Roney's Point,	.....	.....	829
10.	Point Mills,	.....	.....	896
16.	West Alexander,	Penna.	Washington.	1043
21.	Claysville,	.....	.....	1143
28.	Chartier,	.....	.....	.....
32.	Washington,	.....	.....	1049

Fairmont, Morgantown & Pittsburg Branch—B. & O. R. R.

0.	Fairmont,	W. Va.	Marion.	879
1.	Junction Bridge,	....	.....	894
3.	Houlttown,	....	.....	889
4.	Rivesville,	....	.....	888
7.	Prickett's Creek Bri'ge,	....	.....	882
7.	Catawba,	....	.....	880
11.	Opekiska,	....	Monongalia.	.....
17.	Little Falls	....	.....	855
....	Mouth of Tom's Run,	....	.....	822
20.	Round Bottom,	....	.....	837
22.	Uffington,	....	.....	823
26.	Morgantown,	....	.....	816

Monongahela River Railroad.

MONONGAH, W. VA.,
December 1, 1898.

DR. I. C. WHITE, State Geologist,
Morgantown, West Va.

MY DEAR SIR :—In accordance with your recent request I hand you herewith list of stations and elevations on the Monongahela River Railroad, and the West Virginia & Pittsburg Railroad. In the former list we give you the distance to the new B. & O. passenger depot at Clarksburg. In the latter list we begin at the old passenger station. We have no elevation for the new station, neither do I know the exact distance between the old and the new station. This information you will probably get from the data supplied you by the B. & O. R. R. There is a little discrepancy in the elevations between these two Roads owing to the difference in the data furnished by the B. & O., as between Clarksburg and Fairmont. I presume, however, it is sufficiently accurate for the purpose for which you desire it.

Yours truly,
J. A. FICKINGER,
Vice Pres. and Gen. Manager,
Monongahela River Railroad.

Monongahela River Railroad.

Distance.	STATIONS.	State.	County.	Elevation above tide. (Top of rail.)
0.0	Fairm't, (B. & O. depot),	W. Va.	Marion.	879.
1.10	Gaston Junction,	.....	.....	883.50
1.95	Watson,	.....	.....	879.30
2.77	Gaston,	.....	.....	876.50
3.50	Thompson,	.....	.....	884.43
5.87	Monongah,	.....	.....	888.70
7.35	Prichard,	.....	.....	892.22
7.80	Bryan,	.....	.....	888.59
8.80	Highland,	.....	.....	890.74
10.00	Chiefton,	.....	.....	893.00
11.14	Worthington,	.....	.....	893.65
11.86	Hutchinson,	.....	.....	901.50
13.24	Enterprise,	.....	Harrison.	900.62
15.91	Shinnston,	.....	.....	908.80
19.16	Lumberport,	.....	.....	912.23
20.90	Cheswood Park,	.....	.....	916.00
21.60	Maulsby,	.....	.....	921.73
23.31	Clark,	.....	.....	920.50
24.70	Haning,	.....	.....	936.00
25.66	Farnum,	.....	.....	932.21
27.08	Bartlett,	.....	.....	.....
28.02	Glen Falls,	.....	.....	928.50
31.25	W. Va. & P. Junction,	.....	.....	991.96
31.43	Monongahela Junct'n,	.....	.....	.....
31.89	Clarksburg (new B. & O. depot,)	.....	.....	1000.00

West Virginia & Pittsburg Railroad.

0.0	Clarksburg, (Old B. &	W. Va.	Harrison.	....
.....	O. passenger depot.)	....	.....	1030
2.0	West Clarksburg,	....	.....	945
3.2	Monticello,	....	.....	937
6.3	Lynch's Mines,	....	.....	947
8.1	Mt. Clare,	....	.....	1009
11.2	Bond Summit,	....	.....	1174
13.3	Lost Creek,	....	.....	1012
18.5	Jane Lew,	....	Lewis.	1010
21.0	Fisher's Summit,	....	.....	1222
23.4	Riverside,	....	.....	1013
23.8	Deanville,	....	.....	1017
25.4	Weston,(pass. station),	....	.....	1009
26.9	Bendale,	....	.....	1016
28.8	Brownsville,	....	.....	1016
32.4	Rohrbough,	....	.....	1026
36.0	Lias Smith's,	....	.....	1043
37.6	Roanoke,	....	.....	1050
39.6	Arnold,	....	.....	1092
42.3	Peterson,s,	....	.....	847
46.3	Confluence,	....	.....	768
50.7	Burnsville,	....	Braxton.	748
52.7	Coger,	....	.....	758
57.5	Rollyson,	....	.....	783
59.1	Heater,	W. Va.	Braxton.	851
60.9	Berry,	....	.....	906
63.0	Flatwoods,	....	.....	1121
64.6	Hopkins,	....	.....	1006
65.5	Morrison's,	....	.....	1074
68.5	Gillespie,	....	.....	870
70.7	Palmer,	....	.....	899
73.6	Baker's Run,	....	.....	917
75.2	Centralia,	....	.....	933
77.2	Custis,	....	.....	1056
78.4	Brooks Run,	....	.....	1132
84.3	Erbacon,	....	Webster.	1504
85.0	Wainville,	....	.....	1561
87.6	Weese's	....	.....	1706
88.3	Hardwood,	....	.....	1912
91.3	Halo,	....	.....	2062
94.7	Cowen,	....	.....	2229
100.6	Laurel,	....	.....	2039
103.2	Camden-on-Gauley,	....	.....	2018

Sutton Branch, W. Va. & P. R. R.

0.0	Flatwoods,	W. Va.	Braxton.	1121
0.4	Summit,	.....	.....	1165
1.7	McNutt's,	.....	.....	1031
3.5	Karl's Switch,	.....	.....	866
5.6	Sutton,	.....	.....	824

Weston, Buckhannon & Pickens Branch, W. Va. & P. R. R.

0.0	Weston,	W. Va.	Lewis.	1009
3.9	Smith's,	....	.....	.....
5.3	Nicoles,	....	.....	.....
6.1	Gaston,	....	.....	1040
7.0	Seymour,	....	.....	1035
.....	Stone Coal Summit,	....	.....	1444
12.0	Lorentz,	....	Upshur.	1435
16.0	Buckhannon,	....	.....	1405
21.5	Hampton,	....	.....	1412
23.9	Sago,	....	.....	1422
28.9	Ten Mile,	....	.....	1603
32.5	Bean's Mill,	....	.....	.....
34.2	Alton,	.....	.....	1809
37.8	Alexander,	.....	.....	1817
41.6	Newlon,	.....	.....	1910
43.9	Craddock,	.....	.....	1934
45.9	Arvondale Junction,	.....	Randolph.	2227
47.5	McCally's	.....	.....	2324
50.8	Pickens.	.....	.....	2672

Grafton & Greenbrier Railroad.

0.	Grafton,	W. Va.	Taylor.	988
3.	Fresh Ford,	....	.....	988
6.	Foreman's,	....	.....	995
8.	Sandy Creek,	....	.....	1021
11.	Cove Run,	....	.....	1072
14.	Moatsville,	....	Barbour.	1155
17.	Arden,	....	.....	1260
19.	Bryan's, Mill	....	.....	1286
21.	Newman's Trestle,	....	.....	1289
22.	Kelley's,	....	.....	1287
24.	Philippi,	....	.....	1288
42.	Belington,	....	.....	1698

West Virginia Central & Pittsburg Railway.

ELKINS, WEST VA.,
Nov. 26, 1898.

DR. I. C. WHITE, State Geologist,
Morgantown, West Va.

DEAR SIR :—As per instructions from President Davis of this Railroad, I enclose herewith list of stations with elevations and mileage of same. The elevations are above sea level. This, as I understand, complies with request contained in your letter to President Davis under date of November 21st.

Yours truly,
J. W. GALBREATH,
Chief Engineer.

LIBRARY OF THE UNIVERSITY OF CALIFORNIA

West Virginia Central & Pittsburg Railway.

Distance.	STATIONS.	State.	County.	Elevations above tide.
0.0	Cumberland,	Md.	Alleghany.	625.1
1.2	Ridgely,	....	.....	622.0
6.1	Seymour,	....	.....	641.3
9.3	Potomac,	....	.....	664.0
10.4	Frost,	....	.....	.....
11.4	Bier,	....	.....	673.4
12.6	Rawlings,	....	.....	692.3
16.1	Black Oak,	....	.....	724.8
17.4	Gerstell,	....	.....	738.1
18.1	Dawson,	....	.....	743.7
19.0	Green,	....	.....	.....
20.1	Twenty-first,	....	.....	774.8
22.2	Keyser Junction,	....	.....	794.3
27.5	Westernport,	....	.....	904.4
28.8	W. V. C. Junction,	W. Va.	Mineral.	943.6
31.6	Empire,	....	.....	1078.3
33.4	Warnocks,	....	.....	1090.0
34.5	Windom,	....	.....	1129.6
35.1	Barnum,	....	.....	1151.3
38.3	Shaw,	....	.....	1274.9
42.1	Chaffee,	....	.....	1419.4
45.5	Blaine,	....	.....	1560.3
47.2	Harrison,	....	.....	1639.4
52.2	Schell,	....	.....	1943.9
57.8	Stoyer,	Md.	Garrett.	2245.1
59.9	Gorman,	....	.....	2267.2
62.3	Bayard,	W. Va.	Grant.	2331.1
64.8	Wilson,	....	.....	2508.2
66.3	Dobbin,	....	.....	2596.5
67.7	Henry,	....	.....	2647.3
69.7	Wilsonia,	....	.....	2744.9
71.5	Beechwood,	....	.....	2876.6
74.5	Fairfax,	....	.....	3060.1
76.0	William,	....	Tucker.	2967.2
77.7	Thomas,	....	.....	2883.5
79 0	Coketon,	....	.....	2844.5
79.9	Douglas,	....	.....	.....
88.0	Hendricks,	....	.....	1702.1
89.0	Hambleton,	....	.....	1678.6
90.3	Bretz,	....	.....	1657.6
91.4	Parsons,	....	.....	1662.4
94.0	Porter,	....	.....	1694.1
95.2	Moore,	....	.....	.....
99.8	Haddix,	....	.....	2178.1
101.5	Montrose,	....	Randolph.	1995.1
105.8	Kerens,	....	.....	1937.0
107.9	Whyte,	....	.....	1825.3
109.4	Gilman,	....	.....	1920.9
111.0	Read,	....	.....	.....
113.2	Elkins,	....	.....	1920.0
114.4	Elkins Junction,	....	.....	1909.7
115.3	Buxton,	....	.....	1914.0
120.8	Roaring Creek Junct'n,	....	.....	1871.3
121.2	Harding,	....	.....	1846.4

West Virginia Central & Pittsburg Railway.—Continued.

124.3	Laurel,	W. Va.	Randolph.	1753.5
126.9	Junior,	....	Barbour.	1719.0
128.3	Custer,	....	.....	.....
130.8	Belington,	....	.....	1698.5

Davis Branch, W. Va. Central & Pitts. R. R.

0.	Thomas,	W. Va	Tucker.	2883.5
2.6	Child,	....	.....	3010.5
3.8	Pendleton,	....	.....	2988.4
6.3	Davis,	....	.....	3001.4

Elk Garden Branch, W. Va. Central & Pitts. R. R.

0.	Harrison,	W Va.	Mineral.	1639.4
3.3	Switch Back,	....	.....	1930.6
7.0	Elk Garden,	....	.....	2268.2

Beverly and Huttonsville Branch, W. Va. C. & P. R. R.

0.	Elkins,	W. Va.	Randolph.	1920.
1.2	Elkins Junction,	....	.....	1909.7
3.1	Yokum,	....	.....	1926.2
6.7	Beverly,	....	.....	1941.3
8.7	R. R. Bridge over Valley River (top of rail)	....	.....	..... 2015.6
10.0	Crossing Staunton & Parkersburg pike,	....	.....	..... 2021.6
13.8	Crawford House,	....	.....	2046.8
16.3	Mill Creek Bridge,	....	.....	2070.1
17.7	Huttonsville,	....	.....	2077.0

(Preliminary Survey for Gauley River Extension.)

26.	Elk Water,	W. Va.	Randolph.	2358.
32.	Brady's Summit,	....	.....	2992.
34.	Riggles,	....	.....	2714.
35.	Red Lick Run,	....	.....	2429.
36.	Elk River,	....	.....	2331.
38.	Whitacres Falls,	....	.....	2171.
39.	Big Run,	....	.....	2136.
46.	Burgoo,	....	Webster.	1904.
48.	Leatherwood,	....	.....	1841.
56.	Elk River,	....	.....	1583.
59.	Addison,	....	.....	1463.
63.	Payn's Summit,	....	.....	2456.
71.	Gauley River,	....	.....	2308.
78.	Williams River,	....	.....	2215.

Elkins and Buckhannon Branch, W. Va. C. & P. R. R.

(Preliminary Survey.)

0	Elkins,	W. Va.	Randolph.	1920.
7	Roaring Creek,	....	.....	1860.
11	Roaring Creek Sum.	....	.....	2368,

Elkins and Buckhannon Survey, W. Va. C. & P. R. R.—Continued.

12	King's Ridge,	W. Va.	Randolph.	2450
17	Toll Gate,	.....	Upshur.	1851
18	Burnt Bridge,	.....	....	1840
21	White Oak Summit,	.....	....	2031
27	Buckhannon River	.....	....	.....
	Divide,	.....	....	1743
32	Buckhannon,	.....	....	1413

Ohio River Railroad.

PARKERSBURG, W. VA.,
Decmber 7, 1898.

DR. I. C. WHITE, State Geologist,
Morgantown, W. Va.,

DEAR SIR:—Yours of November 21st, addressed to George A. Burt, Vice President and General Manager, referred to me.

The statement enclosed is as full and correct as we are able at this time to make. The elevations from Wheeling to Raven Rock are correct to the tenth, but south of that point the elevations have been deduced from the original levels, and are liable to the inaccuracies that such levels usually are. Datum is mean tide at Sandy Hook.

Hoping this will be satisfactory, I am,
Yours truly,

L. C. JAMES,
Assistant Engineer.

Ohio River Railroad.

Distance.	STATIONS.	State.	County.	Elevations Above Tide.
0.0	Wheeling,	W. Va.	Ohio.	.....
3.3	Riverside,	.....	Marshall.	.....
4.	Benwood,	.....	....	.....
.....	.....	.....	....	....
8.0	Glendale,	.....	... .	648.4
11.3	Moundsville,	.....	....	642.2
14.6	Round Bottom,	.....	....	645.5
15.8	Hornbrooks,	.....	... .	645.2
16.4	Chestnut Hill,	.....	... .	644.2
17.0	Captina Island,	.....	...	643.4
19.2	Powhattan,	.....	... .	646.3
20.2	Cresaps,	.....	... .	642.1
20.5	Underwood,	.....	....	642.0
21.0	Cresap's Grove,	.....	....	640.5
21.5	South Cresap's,	.....	... .	640.6
22.0	Foster,	.....	....	643.2
22.5	Whittaker,	....	... .	644.1
23.2	Woodland,	.....	... .	640.3
25.0	Franklin,	.....	... .	641.2
26.8	Clarington,	.....	... .	637.3

Ohio River Railroad.—Continued.

29.0	Wells' Pit,	W. Va.	Marshall.	636.6
31.5	Proctor,	.....	Wetzel.	636.4
34.0	Alexander,	.....	....	634.6
35.0	Maud,	.....	... .	634.7
35.9	Baresville,	.....	....	632.0
36.5	Bridgeman,	.....	....	632.0
37.4	New Martinsville,	.....	... .	633.7
41.1	Sardis,	.....	... .	628.4
42.0	Paden,	.....	.. ..	629.9
42.7	Paden's Valley,	.....	....	630.0
45.5	Stewart's Crossing,	.....	Tyler.	630.2
47.2	Sistersville,	.....	....	649.6
48.2	Wells,	.....	....	637.4
49.2	Cochransville,	.....	... .	629.8
50.0	Davenport,	.....	....	627.4
51.5	Hays,	.....	... .	625.5
51.8	Friendly,	.....	....	624.3
53.7	Blaine Station,	.....	....	623.9
54.0	Long Reach,	.....	....	624.4
56.0	Selman,	.....	....	622.3
56.2	Ben's Run,	.....	....	621.8
57.0	Engle Rnn,	.....	Pleasants.	625.6
58.0	Edmund,	.....	....	623.8
59.0	Raven Rock,	.....	....	623.1
61.0	Spring Run,	.....	....	621.0
62.0	Grape Island,	.....	....	622.0
64.1	St. Marys,	.....	....	623.0
65.0	Vaucluse,	.....	....	625.0
67.2	Belmont,	.....	....	621.0
69.0	Eureka,	.....	....	628.0
70.6	Salama,	.....	....	623.
71.3	Willow Island,	.....	... .	615.
74.6	Waverly,	.....	Wood.	618.
75.2	James Lane,	.....	....	615.
80.0	Jones,	.....	....	617.
81.4	Williamstown,	.....	... .	609.
83.0	Pohick,	.....	....	610.
85.1	Kellar,	.....	....	613.
86.2	Briscoe,	.....	....	616.
88.9	Vienna,	.....	....	606.
93.6	Parkersburg (elevated	.....	... .	.....
.....	platform,)	.....	....	624.
96.6	Blennerhassett,	.....	....	.....
99.7	Washington,	.....	... .	636.
101.6	Walker's Crossing,	.....	....	.....
102.7	Meldahls,	.....	... .	599.
105.1	New England,	.....	....	.....
105.6	Lamps,	....	... .	.....
107.3	Harris Ferry,	.....	....	595.
109.6	Lee Creek,	.....	....	.....
110.1	Humphrey,	.....	....	.....
111.6	Belleville,	.....	... .	590.
114.9	Lone Cedar,	.....	Jackson.	.....
118.2	Murrayville,	.....	... .	591.
120.1	Williams,	....	....	.....
120.4	Polks,	.....	... .	.....
120.6	Muses Bottom,	.....	.....	586.
121.1	Coleman,	.....	... .	.....

Ohio River Railroad.—Continued.

121.6	Morgan,	W. Va.	Jackson.	.....
123.9	Portland,	....	.....	.....
124.8	Sherman,	....	.....	586
127.1	Turkey Run,	....	.....	.....
128.2	Ravenswood,	....	.....	584
128.8	R. S. & G. Junction,	....	.....	581
132.1	Pleasant View,	....	.....	578
135.3	Willow Grove,	....	.....	582
138.6	Ripley Landing,	....	.....	.....
139.2	Millwood,	....	.....	577
140.6	School House,	....	.....	.....
144.2	Letart,	....	Mason.	574
148.1	Antiquity,	....	.....	.....
149.9	Graham,	....	.....	570
153.0	New Haven,	....	.....	575
154.8	Hartford,	....	.....	569
157.5	Mason City,	....	.....	573
159.2	Clifton,	....	.....	563
161.1	West Columbia,	....	.....	.....
161.9	Spilman,	....	.....	567
164.3	Brownsville,	....	.....	563
166.9	Mackers,	....	.....	575
169.3	Locust Lane,	....	.....	560
172.5	Point Pleasant,	.....	.....	570
174.2	Henderson,	....	.....	563
178.1	Gallipolis Ferry,	....	.....	573
179.1	Beals' Siding,	....	.....	.....
182.1	Elwell,	....	.....	.....
184.0	Ben Lomond,	....	.....	552
185.1	Hogsett,	....	.....	.....
187.5	Apple Grove,	....	.....	570
188.6	Mercer's Bottom,	....	.....	.....
189.6	Ashton,	....	.....	.....
192.5	Glenwood,	....	.....	550
194.1	Lasey's Lane,	....	.....	.....
195.6	McCurdy,	....	Cabell.	.....
198.0	Crown City Ferry,	....	.....	569
200.1	Green Bottom,	....	.....	.....
201.1	Millersport Ferry,	....	.....	.....
202.7	Lesage,	....	.....	548
205.4	Coxe's Landing,	....	.....	548
211.2	Guyandotte,	....	.....	541
214.6	Huntington,	....	.....	538
217.3	Central City,	....	.....	538
221.9	Ceredo,	....	.....	545
223.0	Kenova,	....	.....	550

Ripley and Mill Creek Valley Branch, O. R. R.

0	Millwood,	W. Va.	Jackson.	577
3.0	Cottageville,	....	.....	583
6.0	Angerona,	....	.....	586
8.0	Evans,	....	.....	601
13.0	Ripley,	....	.....	599

Ravenswood, Spencer and Glenville Branch—Ohio R. R.

0.0	Ravenswood,	W. Va.	Jackson.	584
0.6	R. S. & G. Junction,	....	.....	581
1.0	Bridgeport,	....	.....	579
3.1	Silverton,	....	.....	575
6.3	Crow Summit,	....	.....	637
8.6	Sandyville,	....	.....	592
12.2	Meadowdale,	....	.....	611
14.3	Duncan,	....	.....	626
15.1	Leroy,	....	.....	635
17.0	Liverpool,	....	.....	661
19.5	Sandy Summit,	....	Roane.	889
21.7	Seamans,	....	.....	695
22.2	Dukes,	....	.....	684
23.0	Reedy,	....	.....	669
27.0	Hardman,	....	.....	695
30.0	Barrs,	....	.....	899
33.0	Spencer,	....	.....	710

Little Kanawha River.

0.	Parkersb'g(low water),	W. Va.	Wood.	563
2.	Lock One,	....	.....	564
14.	Lock Two,	....	.....	574
22.	Lock Three,	....	Wirt.	584
32.	Lock Four,	....	.....	596
43.	Spring Creek,	....	.....	612
.....	Buffalo Rock,	....	.....	625
.....	Lower Leading Creek,	....	Calhoun.	631
61.	Down's Ripple,	....	.....	635
63.	Anna Maria Creek,	....	.....	641
68.	Big Root,	....	.....	644
76.	Pine Creek,	....	.....	654
78.	Grantsville,	....	.....	656
80.	Steer Creek,	....	.....	666
85.	Acre Island,	....	.....	671
89.	Mussel Shoals,	....	Gilmer.	677
92.	Tanner Fork,	....	.....	682
96.	Cedar Creek,	....	.....	687
98.	Third Run Shoals,	....	.....	689
101.	Leading Creek,	....	.....	690
103.	Glenville,	....	.....	702
105.	Stewart's Creek,	....	.....	702
106,	Mud Lick Run,	....	.....	710
110.	Sand Fork,	....	.....	711
115.	Stout's Mill,	....	.....	723
118.	Hyer's Run,	....	Braxton.	735
121.	Oil Creek,	....	.....	741
122.	Burnsville,	....	.....	741
.....	Bennett's Run,	....	.....	752
131.	Bulltown,	....	.....	760

Chesapeake & Ohio Railroad.

RICHMOND, VA., November 30, 1898.

DR. I. C. WHITE, State Geologist,
Morgantown, West Va.

DEAR SIR :—In response to attached memorandum I hand you herewith a

list of elevations of stations on Main line in West Virginia, above sea level with distances of same from Ft. Monroe. These elevations were copied from grade profile made in Chief Engineer's Office, 1883.

It is not practicable to give elevations on all branches, for the reason that we have no connected levels, but I have added approximate elevations on Loup Creek Branch.

G. A. LYELL,
Chief Draughtsman.

Chesapeake & Ohio Railroad.

Distance. From Ft. Monroe.	STATIONS.	State.	County.	Elevations above tide.
308.3	Tuckahoe,	W. Va.	Greenbrier.	2035
311.9	White Sulphur,	....	....	1922
313.8	Greenbrier,	....	....	1865
315.5	Harts Run,	....	....	1814
316.4	Howard,	....	....	1790
317.3	Caldwell,	....	....	1766
319.8	Whitcomb,	....	....	1698
322.6	Ronceverte,	....	....	1663
326.6	Rockland,	....	....	1650
329.0	Fort Spring,	....	....	1626
330.3	Snow Flake,	....	.....	1607
332.6	Half-Way,	....	....	1579
335.8	Alderson,	....	....	1548
337.9	Mohler,	....	Summers.	1540
339.4	Wolf Creek,	....	....	1530
340.5	Riffe,	....	....	1524
343.6	Stockyards,	....	....	1530
345.3	Lowell,	....	....	1512
347.2	Talcott,	....	....	1512
349.5	Hilldale,	....	....	1496
352.6	Don,	....	....	1432
357.0	Hinton,	....	....	1372
358.8	Tug Creek,	....	....	1352
362.0	Brooks,	....	....	1338
366.6	Sandstone,	....	....	1288
369.6	Meadow Creek,	....	....	1265
374.3	Glade,	....	Fayette.	1236
378.7	Quinnimont,	....	....	1196
380.0	Prince,	....	....	1192
383.1	McKendree,	....	....	1141
385.0	Slater,	....	....	1106
386.0	Buffalo,	....	....	1103
387.0	Alaska,	....	....	1090
387.8	Claremont,	....	....	1086
388.6	Beechwood,	....	....	1078
389.1	Stone Cliff,	....	....	1076
390.8	Thurmond,	....	....	1060
392.2	Dimmock,	....	....	1045
393.2	Beury,	....	....	1038
394.0	Central,	....	....	1029
394.5	Fire Creek,	....	....	1029
396.4	East Sewell,	....	....	1009
397.5	Sewell,	....	....	1003

Chesapeake & Ohio Railroad.—Continued.

399.3	Caperton,	W. Va.	Fayette.	984
400.4	Keeney's Creek,	....	....	965
401.6	Nuttall,	....	....	946
404.3	Fayette,	....	....	900
405.6	Elmo,	....	....	860
406.8	Sunnyside,	....	....	843
407.5	Gaymont,	....	....	832
408.7	Hawks Nest,	....	....	827
409.0	McDougall,	....	....	824
410.8	Cotton Hill,	....	....	792
415.2	Gauley,	....	....	707
417 9	Kanawha Falls,	....	....	669
421.4	Deep Water,	....	....	648
423.0	Digby,	....	....	645
423.6	Mt. Carbon,	....	....	639
424.3	Powellton,	....	....	640
424.6	Diamond,	....	....	641
425.0	Forest Hill,	....	....	642
425.1	St. Clair,	....	....	642
425.3	Eagle,	....	....	641
425.9	Edge Water,	....	....	639
426.6	Crescent,	....	....	638
427.5	Montgomery,	....	Kanawha.	634
428.3	Union Coal Co.	....	....	631
428.7	Consolidated Man'g Co.	....	....	633
429.6	Handley,	....	....	631
430.3	Chesapeake,	....	....	627
431.7	Dego,	....	....	626
432.8	Paint Creek,	....	....	622
432.9	Gordon,	....	....	621
433.5	Crown Hill,	....	....	623
434.1	Belmont,	....	....	620
435.0	Black Cat,	....	....	620
435.6	East Bank,	....	....	625
437.5	Coalburg,	....	....	625
438.1	Cabin Creek,	....	....	616
440.7	Winnifrede Junction,	....	....	616
444.5	Brownstown,	....	....	608
448.2	Malden,	....	....	606
449.8	Kanawha,	....	....	610
451.7	South Ruffner,	....	....	605
453.6	Charleston,	....	....	603
455.2	Elk,	....	....	601
458.4	Black Band,	....	....	598
459.2	Spring Hill,	....	....	597
462.9	Huling,	....	....	594
465.5	St. Albans,	....	....	592
466.9	Lewis,	....	....	592
469.6	Scary,	....	Putnam.	591
473.2	Scott,	....	....	683
475.1	Cades,	....	....	702
476.4	Henderson,	....	....	672
479.2	Hurricane,	....	....	684
480.5	Kibler,	....	....	703
481.5	Culloden,	....	Cabell.	703
484.2	Walton,	....	....	619
485.8	Milton,	....	....	586

Chesapeake & Ohio Railroad.—Continued.

490.3	Ona,	W. Va.	Cabell.	622
491.9	Blue Sulphur Springs,	....	....	598
494.7	Barboursville,	....	....	578
498.2	Wilson,	....	....	556
501,0	Guyandotte,	....	....	560
501.2	D. K. Tower,	....	....	563
504.0	Huntington,	....	....	566
506.1	Central City,	....	....	540
508.5	Kellogg,	....	Wayne.	544
510.7	Ceredo,	....	....	545
511.8	Kenova,	....	....	550

Loup Creek Branch—C. & O. R. R.

390.8	Thurmond,	W. Va.	Fayette.	1060
396.0	Harvey,	....	.....	1555
397.0	Red Star,	....	.....	1601
398.0	Glen Jean,	....	.....	1611
400.0	Dun Loup,	....	.....	1652
400.5	Turkey Knob,	....	.....	1677
401.5	MacDonald.	....	.....	1678

Elk River.

0	Charleston (low water)	W. Va.	Kanawha.	556
21	Big Sandy Creek,	....	....	591
24	Queen's Shoals,	....	....	611
60	Big Otter Creek,	....	Clay.	726
70	Grove's Creek,	....	....	751
80	Birch River,	....	Braxton.	770
93	Little Otter Creek,	....	....	794
...	Beall's Mills,	....	....	798
100	Sutton,	....	....	806

Gauley River.

0	Mouth of River, (low water,)	W. Va.	Fayette.	 650
5	Twenty Mile Creek,	.....	....	....
..	(mouth)	.....	....	667
10	Little Elk Creek,	.....	Nicholas.	691
15	Peters,	.....	....	879
21	Carnifax Ferry,	.....	....	1208
25	Hughes Ferry,	.....	....	1546
29	Brock's,	.....	....	1589
31	Beaver Creek,	....	....	1694
40	Cherry River,	.....	....	1777
43	Cranberry,	.....	....	1915
46	Stroud s Ferry,	.....	....	2009
55	Williams River,	.....	Webster.	2167
75	Laurel Fork,	.....	Pocahontas.	3011
80	Stony Creek,	.....	....	3223
85	Marlin's Bottom,	.....	.....	2120

Norfolk & Western Railway.

ROANOKE, VA., December 13th, 1898.

DR. I. C. WHITE, State Geologist,
Morgantown, West Va.,

DEAR SIR :—Your letter of Nov. 21st addressed to the President of the N. & W. Ry. Co. has been referred to me :

In answer, I attach hereto a list of the stations with elevations of same in the State of West Virginia ; the elevations being uniformly at sub-grade. To get the elevation of base of rail seventeen inches must be added. Probably for publication purposes one foot would be best to use, although this elevation depends on the amount of ballast we have under track. Wherever our track is standard ballasted this distance would be one and four-tenths feet above the sub-grade. The elevations given are the heights of sub-grade above mean low water at Norfolk.

Yours truly,

CHAS. J. CHURCHILL,
Eng. M. of Way.

Norfolk & Western Railway.

Distance. from Norfolk.	STATIONS.	State.	County.	Elevation above tide.
342.41	Wills,	W. Va.	Mercer,	1614
346.96	Oakvale,	.....	.....	1708
351.08	Hardy,	.....	....	1865
352.73	Ingleside,	.....	....	1944
353.89	East River,	.....	....	1990
356.95	Tulip,	.....	....	2139
358.73	Ada,	.....	....	2218
363.08	Bluefield,	.....	....	2556
372.26	Abbs Valley,	.....	....	2291
372.92	Dayton,	.....	....	2287
373.84	Bluestone Junction,	.....	....	2281
374.94	Wood,	.....	....	2272
375.29	Cooper,	.....	....	2266
376.37	Ruth,	.....	....	2359
376.80	E. End Tunnel,	.....	....	2384
377.42	Coaldale,	.....	....	2336
379.53	Maybeury,	.....	McDowell,	2147
380.39	Switchback,	.....	....	2070
381.40	Ennis,	.....	....	1995
382.94	Elkhorn,	.....	....	1882
384.36	Powhatan,	.....	....	1796
385.00	Kyle,	.....	....	1760
385.99	North Fork Junction,	.....	....	1700
387.4	Keystone,	.....	....	1635
388.35	Eckman,	.....	....	1588
389.30	Landgroff,	.....	....	1569
390.84	Vivian,	.....	....	1515
391.54	Vivian Yard,	.....	....	1494
392.40	Norwood,	.....	....	1475
396.44	Huger,	.....	....	1340
399.2	Welch,	.....	....	1297
400.29	Hemphill,	.....	....	1285
406.76	Davy,	.....	....	1183
412.86	Roderfield,	.....	....	1092

Norfolk & Western Railway.—Continued.

417.70	Wilmore,	W. Va.	McDowell.	1019
421.88	Iager,	....	....	978
429.29	Panther,	....	....	939
432.10	Wyoming,	....	....	924
434.00	Alnwick,	....	Mingo.	897
437.88	Wharncliffe,	....	....	826
439.80	Glen Alum,	....	....	806
442.78	Gray,	....	....	778
446.59	Devon,	....	....	754
450.87	Sands,	....	....	732
453.73	Delorme,	....	....	720
456.21	Thacker,	....	....	709
460.70	Matewan,	....	....	690
465.80	Rawl,	....	....	672
469.59	Williamson,	....	....	658
473.42	Barger,	....	....	650
477.63	Nolan,	....	....	643
484.40	Naugatuck,	....	....	630
488.70	Leware,	....	....	635
492.01	Canterbury,	....	....	675
496.53	Hale,	....	....	880
498.85	Dingess,	....	....	1001
501.11	Trace,	....	....	915
507.27	Breeden,	....	....	811
512.28	Wilsondale,	....	Wayne.	755
516.59	Doane,	....	....	717
519.77	Wells Branch,	....	....	701
522.27	Dunlow,	....	....	688
527.29	Ferguson,	....	....	666
528.89	Radnor,	....	....	662
533.40	Genoa,	....	....	643
536.48	Coleman,	....	....	626
538.86	Echo,	....	....	607
543.27	Wayne,	....	....	598
549.30	Ardel,	....	....	585
552.67	Dickson,	....	....	575
555.62	Lavalette,	....	....	561
561.38	Bufflalo Creek,	....	....	556
566.67	Ceredo,	....	....	565
567.92	Kenova.	....	....	580

Bluestone Branch—N. & W. Railway.

0.00	Bluestone Junction,	W. Va.	Mercer.	2281
1.47	Pocahontas,	....	....	2315

Cooper and Goodwill Branch—N. & W. Railway.

0.00	Cooper,	W. Va.	Mercer.	2266
1.16	Bramwell,	....	....	2247
1.80	Simmons Creek Junc'n,	....	....	2242
5.48	Johnson's,	....	....	2216
5.96	Flipping Creek Junc'n,	....	....	2210
6.35	Duhring,	....	....	2215
7.91	Goodwill,	....	....	2262

North Fork Branch—N. & W. Railway.

0.00	North Fork Junction.	W. Va.	McDowell.	1699
0.66	Algoma.	....	....	1755
1.49	Gillian,	....	....	1796
2.75	Rolfe,	....	....	1869
3.98	Arlington,	....	....	1939
4.40	McDowell,	....	....	1968
6.12	Ashland.	....	....	2140

Shenandoah Division—Norfolk & Western Railway.

Distance from Hagerstown.	STATIONS.	State.	County.	Elevation above tide.
0.63	Cumberl'd V'l'y Junct.	Md.	Washington.	575.
16.82	Sheperdstown,	W. Va.	Jefferson.	497.
17.71	Morgan's Grove,	....	....	428.
23.10	Shenandoah Junction,	....	....	.....
.....	(B. & O.,)	....	....	509.
24.47	Aglionsby,	....	....	526.
27.94	Valley Branch, (B. &	....	....	.....
.....	O. Crossing)	....	....	492.
28.32	Charlestown,	....	....	512.
32.56	Wheatland,	....	....	501.
33.70	Rippon,	....	....	514.

Ohio Central Railroad—Kanawha & Michigan Division.

Distance.	STATIONS.	State.	County.	Elevation above tide.
0	Charleston,	W. Va.	Kanawha.	600
4	Lock No. 6,	....	....	592
7	Smith's,	....	....	588
10	Ryans,	....	....	588
12	Sattes,	....	....	586
15	Bowling,	....	Putnam.	584
18	Poca,	....	....	579
19	Raymond City,	....	....	586
20	Queen City,	....	....	579
21	Energetic,	....	....	576
26	Red House,	....	....	577
31	Martins,	....	....	572
35	Buffalo,	....	....	570
38	18-Mile Creek,	....	....	564
40	Grimm's,	....	Mason.	563
42	Maupin's,	....	....	570
45	Leon,	....	....	567
48	Beech Hill,	....	....	562
50	Bright's,	....	....	564
51	Rock Castle,	....	....	563
56	River Switch,	....	....	557
57	Ohio River Bridge at	....	....	...
..	Point Pleasant.	....	....	597

Pittsburg, Cincinnati & St. Louis R. R.—Pittsburg, Wheeling & Kentucky Division.

0.	Steubenville,	Ohio.	Jefferson.	728
1.	Wheeling Junction,	W. Va.	Brooke.	....
3.	Middle Ferry,	....	....	....

Pittsburg, Cincinnati & St. Louis Railroad—Pittsburg, Wheeling & Kentucky Division.—Continued.

4	Lower Ferry,	W. Va.	Brooke.	...
6	Cross Creek,	.....	....	...
9	Wellsburg,	.....	....	...
12	Beech Bottom,	.....	....	...
16	Short Creek,	.....	Ohio.	...
21	Glenns,	.....	....	...
25	Wheeling,	.....	....	645

Pittsburg, Washington & Southern Railroad Survey.

(Levels on preliminary survey from Waynesburg, Pa., to Mannington, W. Va.)

0	Waynesburg, (W. & W.	Penna.	Greene.	....
....	R. R.)	....	....	943
0.1	Ten Mile Creek,	....	....	922
2.6	Inghram's School	....	....	....
....	House,	....	....	991
4.6	Road at Orndoffs,	....	....	1040
6.3	Road on Brant's Sum-	....	....	....
....	mit,	....	....	1300
7.2	Private Road at Brick	....	....	....
....	House,	....	....	1127
8.0	Bench Mark, Sugar,	....	....	....
....	Caleb Spragg's Or-	....	....	....
....	chard,	....	....	1084
8.5	Road in Spraggtown,	....	....	1065
9.2	B. M. 1st bridge Ro-	....	....	....
....	bert's Run below	....	....	....
....	Spraggtown,	....	....	1050
10.1	Road, upper end John	....	....	....
....	T. Rinehart's land,	....	....	1031
10.5	B. M., Sycamore be-	....	....	....
....	tween Rinehart's and	....	....	....
....	Thralls,	....	....	1023
11.9	B. M., N. E. corner	....	....	....
....	bridge at William	....	....	....
....	Mapel's,	....	....	990
12.1	Johnson's school house,	....	....	985
12.2	Derrick on Johnson	....	....	....
....	farm,	....	....	(?) 973
13.2	Roberts Run bridge at	....	....	....
....	Blacksville,	W. Va.	Monongalia.	955
13.6	Washington coal along	....	....	....
....	road up Dunkard,	....	....	985
14.3	Wright's Run,	....	....	957
14.7	Barber Spring,	....	....	968
15 0	B. M., Miracle Run	....	....	....
....	bridge on Dunkard	....	....	....
....	creek,	....	....	968
15.0	Dunkard Creek, (low	....	....	....
....	water),	....	....	950
15.6	Road above Eliab Ten-	....	....	....
....	nant's,	....	....	968

Pittsburg, Washington & Southern Railroad Survey.—Continued.

16.0	Road at J. C. Thomas'	W. Va.	Monongalia.	....
....	scales,	....	....	978
16.8	B. M. on bridge at Bula	....	....	....
....	P. O.,	....	....	983
17.6	Road in front of Isaac	....	....	....
....	Strosnider's,	....	....	985
18.0	Ground back of Ebene-	....	....	....
....	zer Bell's house,	....	....	995
18.5	Road in front of Eli	....	....	....
....	Collin's house,	....	....	1005
19.1	Road in bend above	....	....	....
....	Jonathan Fox's,	....	....	1010
19.5	Old road at Josiah	....	....	....
....	Thomas's,	....	....	1013
20.0	Miracle Run on Z. S.	....	....	....
....	Wise's farm,	....	....	1015
20.3	Road at Lewis Fox's,	....	....	1031
21.3	B. M. N. W. corner of	....	....	....
....	E. Eddy's stable,	....	....	1048
21.4	Road (Jollytown coal	....	....	....
....	12 ft. above,)	....	....	1051
21.5	Pike in Cross Roads,	....	....	1056
22.0	B. M. on School House	....	....	....
....	at Corrother's,	....	....	1057
22.9	Miracle Run, E. Ten-	....	....	....
....	nant's sugar camp,	....	....	1071
23.7	Road, lower end of Sol.	....	....	....
....	Shriver's farm,	....	....	1097
24.2	Run at Isaac Efaw's	....	....	....
....	stable,	....	....	1134
25.7	Road at Fly Blow,	....	Marion.	1431
27.4	Coal on Jones farm,	....	....	....
....	(probably Jolly-	....	....	....
....	town),	....	....	1175
27.5	B. M., White Oak, Hog	....	....	....
....	Back, Riley Dicken's	....	....	....
....	farm,	....	....	1162
28.1	40 feet above Run at	....	....	....
....	Nancy Thomas',	....	....	1085
29.0	B. M., White Oak, Flat	....	....	....
....	Run Baptist Church,	....	....	1016
29.4	Road at Flat Run P.O.,	....	....	1006
30.0	Road, level with der-	....	....	....
....	rick, W.B. Sine farm,	....	....	993
30.7	Road, bend below Cun-	....	....	....
....	ningham's, (Wash.	....	....	....
....	coal 2 ft. above,)	....	....	984
31.2	Pyles Fork (low water,)	....	....	974
31.9	Prichard's Run,	....	....	979
32.8	Mannington, B. & O.	....	....	....
....	depot, top of rail,	....	....	978

West Virginia Short Line Railroad Survey.

CLARKSBURG, W. VA.,
January 20, 1899.

DR. I. C. WHITE, State Geologist,
Morgantown, W. Va.,

DEAR SIR:—In reply to your request I herewith send you a table of distances and elevations of points on the West Virginia Short Line Railroad Survey. In one column is given the elevation of the top of the rail, while in the other column is the elevation of low water in the streams along the line at the points named. The elevations given are above sea level, based on the Government levels on the Ohio River. The published levels of the B. & O. R. R. in Clarksburg would make these elevations 1.5 feet lower than here shown.

Yours very truly,
T. M. JACKSON,
President.

West Virginia Short Line Railroad Survey.

Dis.	STATIONS.	State.	County.	Elevations.	
				Top of rail.	Low water.
0.0	North end Third St.,	W. Va.	Harrison.	....	....
....	Clarksburg,	....	.....	983	....
0.3	College St., Clarksburg,	....	.....	975	....
0.5	West end Elk Creek	....	.....	....	....
....	bridge,	....	.....	968	923
0.9	West end West Fork	....	.....	....	....
....	bridge,	....	....	966	910
1.4	West end Limestone	....	.....	....	....
....	bridge,	....	.....	967	912
2.5	West end Crooked Run	....	.....	....	....
....	bridge,	....	.....	984	922
5.5	Hepzibah Summit (top	....	.....	....	....
....	of cut, elevation 1063)	....	.....	1031	....
7.2	West end Lambert Run	....	.....	....	....
....	bridge,	....	.....	986	899
8.9	West end Wolf Pen	....	.....	....	....
....	Run bridge,	....	.....	961	897
10.0	West end Ten Mile	....	.....	....	....
....	Creek, 1st Crossing	....	.....	....	....
....	(below Fortney's,)	....	.....	927	883
10.2	West end Ten Mile	....	....	....	....
....	Creek, 2nd Crossing	....	.....	....	....
....	(above McDemott's)	....	.....	925	888
10.6	West end Ten Mile	....	.....	....	....
....	Creek, 3rd Crossing	....	.....	....	....
....	(near school house,)	....	.....	925	897
11.6	West end Ten Mile	....	.....	....	....
....	Creek, 4th Crossing	....	.....	....	....
....	(below widow Robin-	....	.....	....	....
....	son's)	....	.....	931	899

West Virginia Short Line Railroad Survey.—Continued.

11.8	West end Ten Mile	W. Va.	Harrison.	....	.....
....	Creek, 5th Crossing,	....	....	....	.....
....	(above widow Robin-	....	....	....	.....
....	son's),	....	....	932	901
13.2	West end Little Ten	....	....	....	.....
....	Mile Creek, 1st cross-	....	....	....	.....
....	ing, (on T. J. Robey),	....	....	933	913
14.3	West end Little Ten	....	....	....	.....
....	Mile Creek, 2d cross-	....	....	....	.....
....	ing, (on A.G.Swiger),	....	....	947	926
15.1	West end Little Ten	....	....	....	.....
....	Mile Creek, 5th cross-	....	....	....	.....
....	ing, (just below Dola)	....	....	957	942
15.9	West end Little Ten	....	....	....	.....
....	Mile Creek, 6th cross-	....	....	....	.....
....	ing, (just above Dola)	....	....	966	951
16.9	West end Little Ten	....	....	....	.....
....	Mile Creek, 7th cross-	....	....	....	.....
....	ing, (above Ritten-	....	....	....	.....
....	house),	....	....	974	959
17.3	West end Little Ten	....	....	....	.....
....	Mile Creek, 9th cross-	....	....	....	.....
....	ing, (near Edgell's),	....	....	982	969
18.0	West end Little Ten	....	....	....	.....
....	Mile Creek, 10th cross-	....	....	....	.....
....	ing, (below Brown-	....	....	....	.....
....	town),	....	....	991	976
18.6	West end Little Ten	....	....	....	.....
....	Mile Creek, 11th cross-	....	....	....	.....
....	ing, (below Marsh's,)	....	....	1000	985
19.3	West end Little Ten	....	....	....	.....
....	Mile Creek, 12th cross-	....	....	....	.....
....	ing (above Marsh's,)	....	....	1009	990
20.6	West end Little Ten	....	....	....	.....
....	Mile Creek, 14th cross-	....	....	....	.....
....	ing, (near Robinson's	....	....	....	.....
....	Mill,)	....	....	1030	997
21.9	West end Mud Lick	....	....	....	.....
....	Creek, 1st crossing,	....	....	....	.....
....	(at Barnes',)	....	....	1053	1018
23.1	East end of Tunnel,	....	....	1075	.....
23.7	West end of Tunnel,	....	Wetzel.	1077	.....
25.7	West end Fishing Cr'k,	....	....	....	.....
....	1st crossing, (on Da-	....	....	....	.....
....	vid Talkington,)	....	....	990	950
26.3	West end Talkington	....	....	....	.....
....	Run crossing,	....	....	963	922
27.6	West end Fishing Cr'k,	....	....	....	.....
....	3rd crossing, (on J.	....	....	....	.....
....	W. Starkey,)	....	....	903	873
28.3	West end Fishing Cr'k,	....	....	....	.....
....	4th crossing (on An-	....	....	....	
....	son Cain,)	....	....	872	857
29.9	West end Fishing Cr'k,	....	....	....	.....
....	5th crossing, (at	....	....	....	.....
...	Smithfield,)	....	....	833	820

West Virginia Short Line Railroad Survey.—Continued.

30.9	West end Falling Tim-	W. Va.	Wetzel.	.....	.....
....	ber Creek crossing,	.....	.....	.....	.....
....	(on Edgell's heirs,)	.....	.....	823	811
31.5	West end Fishing Cr'k,	.....	.....	.....	.....
....	7th crossing at Ar-	.....	.....	.....	....
....	chie's Fork,	.....	.....	819	801
33.0	West end Fishing Cr'k,	.....	.....	.....	.....
....	8th crossing. (on Lew-	.....	.....	.....	.....
....	is Wyatt,)	.....	.....	802	782
33.6	West end Fishing Cr'k,	.....	.....	.....	.....
....	9th crossing, (on Al-	.....	.....	.....	.....
....	pheus Wyatt,)	.....	.....	792	772
35.4	West end Fishing Cr'k,	.....	....	.....	.....
....	10th crossing, (at Mor-	.....	.....	.....	....
....	gan Low Gap,)	.....	.....	770	749
36.5	West end Buffalo Cr'k	.....	.....	.....	.....
....	crossing,	.....	.....	749	731
37.4	West end Wyatt Run	.....	.....	.....	.....
....	crossing, (Madison	.....	.....	.....	.....
....	Baker's,)	.....	.....	737	728
39.2	West end Fishing Cr'k,	.....	.....	.....	.....
....	12th crossing (below	.....	.....	.....	.....
....	Amos Lowe's house,)	.....	.....	731	707
39.7	West end Fishing Cr'k,	.....	.....	.....	.....
....	15th crossing (1 mile	.....	.....	.....	.....
....	above Pine Grove,)	.....	.....	723	701
40.6	West end Fishing Cr'k,	.....	.....	.....	.....
....	16th crossing at Pine	.....	.....	.....	.....
....	Grove,	.....	.....	718	695
43.2	West end Piney Fork	. .	.....	.....	.. ...
....	Creek branch crossing	.....	.....	.....	..
....	(on Long & Wiley,)	.....	.....	698	680
44.4	West end Crow Run	.....	.....	.....	.....
....	crossing, (on John	.....	.....	.....	.....
....	Lantz,)	.....	.....	690	677
45.2	West end Brush Run	.....	.....	.....	.....
....	crossing (opposite	.....	.....	.....	.....
....	Reeder,)	. ....	.....	689	676
47.1	West end Fishing Cr'k,	.....	.....	.....	.....
....	17th crossing, (just	.....	.....	.....	.....
....	above Long Point,)	.....	.....	687	660
47.6	West end Fishing Cr'k,	.....	.....	.....	.....
....	18th crossing (be-	.....	.....	.....	.....
....	tween tunnels,)	.....	.....	685	650
47.8	West end State Road	.....	.....	.....	.....
....	Run crossing (on	.....	.....	.....	.....
.,.	Long heirs,)	.....	.....	682	665
48.2	West end Fishing Cr'k,	.....	.....	.....	.....
....	19th crossing (above	.....	.....	.....	.....
....	Porter's Falls,)	.....	.....	678	650
49.2	West end Fishing Cr'k,	.....	.....	.....	.....
....	20th crossing (on	.....	.....	.....	.....
....	Aaron Morgan,)	.....	.....	673	640
51.7	West end Fluharty Run	.....	.....	.....	.....
....	crossing (opposite	.....	.....	.....	.....
....	Minnie,)	.....	.....	646	632

West Virginia Short Line Railroad Survey.—Continued.

59.2	Ohio River R. R. track	W. Va.	Wetzel.	....	....
....	at Junction, just be-	....	....	....	....
....	low New Martins-	....	....	....	....
....	ville,	....	....	629	....
....	Low water, Ohio river,	....	....	....	....
....	at Bowman, 2 miles	....	....	....	....
....	below New Martins-	....	....	....	....
....	ville,	....	....	....	591

Part III.

VARIATION OF THE MAGNETIC COMPASS.

True Meridian Lines in the Several Counties of the State.

As already stated in the Administrative part of this Bulletin, the work of determining the variation of the magnetic compass in the several counties of the State, and marking the true meridian or north and south line with stone monuments and metal tablets, in or near each county seat has been accomplished through co-operation with the United States Geological Survey under a contract entered into by the West Virginia Survey with Director Walcott of the National Survey. The result of this co-operative work, together with a short discussion of magnetic declination, and methods of determining the same, by Mr. R. U. Goode, Geographer of the U. S. G. Survey, follows the accompanying letter of Director Walcott :

WASHINGTON, D. C., January 7th, 1899.

PROFESSOR I. C. WHITE, State Geologist.
Morgantown, West Virginia.

DEAR SIR :—I have the honor to enclose herewith a report relating to the establishment of meridian marks in West Virginia by this organization.

The report has been prepared by Mr. Richard U. Goode, Geographer, and includes some information previously sent you in a letter, as it was thought desirable to embrace all the material relating to the subject.

Very respectfully,

(Signed) CHAS. D. WALCOTT,
Director.

DISCUSSION OF MAGNETIC DECLINATION,

By

R. U. GOODE, Geographer, U. S. G. Survey.

Under the terms of the co-operative agreement for the establishment of meridian marks at county seats in West Virginia entered into by the State Geologist and the Director of the U. S. Geological Survey on December 2, 1897, the field work of establishing these marks was begun early in June by Mr. George T. Hawkins, Topographer, U. S. Geological Survey, under the direction of Mr. H. M. Wilson, Geographer.

Mr. Hawkins determined 11 azimuth lines and marked them with stone monuments. Early in July he was relieved from further work by Mr. E. L. Faison, of the U. S. Geological Survey, who was actively engaged until December 14th, at which time the determination of the last azimuth mark at New Cumberland was completed. In addition to the above, one azimuth mark was established by Mr. W. J. Peters, Topographer, U. S. Geological Survey, at Berkeley Springs.

At various times since 1864 the U. S. Coast and Geodetic Survey has established meridian marks at twelve county seats in West Virginia. The U. S. Geological Survey during the past season established meridian marks at the remaining forty-three county seats.

The field work required the uninterrupted services of one astronomer for a period slightly exceeding six months. The cost of this work has been $1,505, or for

the 43 stations established by this bureau, at the rate of $35 per county, which cannot be considered a high figure considering the distances traveled and the many interruptions and difficulties of conducting astronomic observations at all hours of the night and in all kinds of weather. This sum includes not only the services of the astronomer with his living and traveling expenses, but also the cost of cutting and planting in the ground two stone monuments at each county seat.

Of the above sum there was allotted by the State of West Virginia $500, of which $499.96 were expended. The remainder was provided from the appropriation for the work of the U. S. Geological Survey.

The results are marked on the ground by stone monuments at distances of from 300 feet to nearly a mile apart. These monuments are four feet in length and are buried so as to leave 6 inches projecting, the upper surfaces being dressed to a cubical form 6 inches on a side. In the center of the northern mark is embedded an alumnium tablet which is stamped $\frac{U.\ |\ S.}{W.\ |\ V.}$ the center of the cross marking the northern end of the meridian line. In the center of the southern or station mark is embedded a bronze tablet. On this is cast the legend "U. S. GEOLOGICAL SURVEY, W. VA. MERIDIAN MARK." On its center is cut a true north and south line pointing to the north or distant mark, while places are provided for stamping the elevation above sea level when they shall be determined by future surveys. In addition, as shown in the table published herewith, the magnetic declination was determined at each station.

The instrument used was a micrometer transiting theodolite reading to two seconds.

The following tabular statement gives the magnetic

declination at the several county seats in the 55 counties of West Virginia, together with the dates at which the observations were made, name of observer, etc.:

Location of Meridian Marks and Magnetic Declinations, West Virginia.

County.	Location.	Date.	Declination West.	Authority.
Barbour,	Philippi,	July 26. 27, '98.	3°27′	U. S. C. & G. S.
Berkeley,	Martinsburg,	May 27, '98.	4 27	G. T. Hawkins.
Boone,	Madison,	Aug. 29, '98.	2 11	E. L. Faison.
Braxton,	Sutton,	June 29, '98.	2 16	U. S. C. & G. S.
Brooke,	Wellsburg,	Dec. 14, '98.	1 34	E. L. Faison.
Cabell,	Huntington,	May 30, 31, '98.	0 51	U. S. C. & G. S.
Calhoun,	Grantsville,	July 22, '98.	1 15	E. L. Faison.
Clay,	Clay,	Nov. 12. '98.	1 21	" "
Doddridge,	West Union,	July 12, '98.	2 20	" "
Fayette,	Fayetteville,	Nov, 8, '98.	1 28	" "
Gilmer,	Glenville,	July 17, '98.	2 08	" "
Grant,	Petersburg,	June 14, '98.	3 37	G. T. Hawkins.
Greenbrier,	Lewisburg,	Oct. 22, '98.	1 41	E. L. Faison.
Hampshire,	Romney,	June 10, '98.	2 46	G. T. Hawkins.
Hancock,	New Cumberl'd	Dec. 15, '98.	1 38	E. L. Faison
Hardy,	Moorefield,	June 12, '98.	3 37	G. T. Hawkins.
Harrison,	Clarksburg,	June 24, 25, '98.	2 50	U. S. C. & G. S.
Jackson,	Ripley,	Nov. 25, '98.	1 25	E. L. Faison.
Jefferson,	Charlestown,	June 6, '98.	3 32	G. T. Hawkins.
Kanawha,	Charleston,	June 7, 8, '98.	1 57	U. S. C. & G. S.
Lewis,	Weston,	July 6, '98.	2 31	" "
Lincoln,	Hamlin,	Nov. 15, '98.	1 32	E. L. Faison.
Logan,	Logan,	Aug, 31, '98.	1 31	" "
McDowell,	Welch,	Oct. 31, '98.	1 48	" "
Marion,	Fairmont,	July 4, '98.	3 21	" "
Marshall,	Moundsville,	Dec. 10, '98.	1 07	" "
Mason,	Point Pleasant,	Nov. 20, '98.	1 21	" "
Mercer,	Princeton,	Oct. 28, '98.	1 33	" "
Mineral,	Keyser,	June 21, '98.	3 57	G. T. Hawkins.
Mingo,	Williamson,	Nov. 4, '98.	1 42	E. L. Faison.
Monongalia,	Morgantown,	June 30, '98.	3 21	" "
Monroe,	Union,	Oct. 25, '98.	1 43	" "
Morgan,	Berkeley Spr'gs	Nov. 21, '97.	4 36	W. J. Peters.
Nicholas,	Summersville,	Aug. 25, '98.	3 14	E. L. Faison.
Ohio,	Wheeling,	July 21, '98.	1 01	U. S. C. & G. S.
Pendleton,	Franklin,	June 18, '98.	2 43	G. T. Hawkins.
Pleasants,	St. Marys,	Nov. 30, '98.	1 04	E. L. Faison.
Pocahontas,	Marlinton,	Aug. 16, '98.	3 31	" "
Preston,	Kingwood,	June 26, '98.	3 39	G. T. Hawkins.
Putnam,	Winfield,	Nov. 18, '98.	1 30	E. L. Faison.
Raleigh,	Beckley,	Oct. 11, '98.	1 42	" "
Randolph,	Beverly,	July, 29, '98.	2 45	U. S. C. &. G. S.
Ritchie,	Harrisville,	June 21, 22, '98.	1 29	U. S. C. &. G. S.
Roane,	Spencer,	July 28, '98.	1 43	E. L. Faison.

LIBRARY OF THE UNIVERSITY OF CALIFORNIA

Summers,	Hinton,	Oct. 20,	'98.	1 22	E. L. Faison.
Taylor,	Grafton,	June 23,	'98.	3 38	G. T. Hawkins.
Tucker,	Parsons,	July 7,	'98.	3 22	E. L. Faison.
Tyler,	Middlebourne.	Dec. 3,	'98.	1 36	" "
Upshur,	Buckhannon,	July 1, 2,	'98.	3 00	U. S. C. & G. S.
Wayne,	Wayne,	May 26,	'98.	0 45	" "
Wayne,	Dunlow,	May 23,	'98.	1 11	" "
Webster,	Addison,	Aug. 21,	'98.	3 16	E. L. Faison.
Wetzel,	New Mart'sv'le	Dec. 8,	'98.	0 59	" "
Wirt,	Elizabeth,	Nov. 28,	'98.	2 28	" "
Wood,	Parkersburg,	June 17, 18,	'98.	1 14	U. S. C. & G. S.
Wyoming,	Oceana.	Oct. 5,	'98.	1 37	E. L. Faison.

The magnetic declination at any place may be stated as being the angle between two vertical planes, one representing the true or astronomic north and the other the magnetic north, or the direction a freely suspended magnet—the needle in the case of a compass—would assume. The former plane is represented by the meridian marks established at the various county seats as described above, and the latter by the needle when the surveyor's instrument is placed in the meridian. Thus if an ordinary compass was set over the mark on the south stone and a sight taken to the mark on the north stone the reading of the needle would define the magnetic declination.

The declination is affected by the elements of space and time. Thus, in different portions of West Virginia at present there are different variations, as may be seen from the table of magnetic declinations, ranging from about 4° 36′ at Berkeley Springs, in the eastern portion of the State, to 0° 45′ at Wayne, in the western portion of the State. In the same way with regard to time, different variations have existed at the same place at different times in West Virginia. The line passing through the points on the earth's surface at which no declination exists is termed the agonic or line of no declination. This line in the first decade of the present century probably entered West Virginia and during

the century has passed entirely across the State, so that while at the early portion of the century the declination throughout the State was to the eastward it is now uniformly to the westward. This gradual changing of the magnetic declination is termed the secular variation and in West Virginia is at the rate approximately of 3 minutes per annum. By applying this correction to the table of magnetic declinations published above the declination at the places indicated may be closely approximated at any time in the future. Thus at Philippi in Barbour county the declination in July, 1898, was 3° 27′ W. If it was desired to find what the declination would be at the same place in January, 1900, a correction of +4½′ would be applied. As the declination is uniformly increasing throughout the State of West Virginia all corrections will be affected by a plus sign.

By collecting all data which has been obtained in the past in regard to the magnetic declination in West Virginia it has been possible to prepare a table which can be used with a fair degree of approximation for the purpose of ascertaining the conditions existing at any particular time within the limits of the table. Such a table was prepared and published in the Seventeenth Annual Report of the Director of the U. S. Geological Survey and is given below:

YEAR	REDUCTION	YEAR	REDUCTION
1890	+0°30′	1840	+3°30′
1880	+1 00	1830	+4 00
1870	+1 55	1820	+4 10
1860	+2 55	1810	+4 20
1850	+3 00		

The table is the reduction to the epoch 1900 on account of the secular variation.

As an example to illustrate how this table may be used in correcting a recorded bearing as a result of an old survey, the following is given, a case being taken in each quadrant:

The reduction from 1810 to 1900 being +4°20′	
The magnectic bearing of a line in 1810.	Reduces to the magnetic bearing in 1900.
N. 30°40′ E.	N. 35°00′ E.
S. 30 40 W.	S. 35 00 W.
N. 35 00 W.	N. 30 40 W.
S. 35 00 E.	S. 30 40 E.

There are other agencies influencing the magnetic declinations sufficiently to produce some irregularities, but for the purposes of the county surveyor no change other than that of secular variation referred to above need, under ordinary circumstances, be taken into consideration. The diurnal change is one, however, of some importance, as it may produce changes from 10 to 15 minutes, being highest in the morning at 7 or 8 o'clock and least in the early afternoon, returning to its maximum position at 8 or 9 o'clock in the evening. There are likewise monthly and annual changes, but these are of negligible consequence. Magnetic storms also seriously affect the needle at various times, causing temporary changes which are sometimes of considerable magnitude. Then there is the trouble with which all surveyors are familiar caused by the presence of substances, either natural or artificial, below or above

the surface, which at times are perplexing to those who are endeavoring to obtain satisfactory results from the use of the needle.

Owing to the above influences, the results of compass surveys will always be affected by a considerable probable error. Whenever the transit is available it is highly preferable to run a line by deflection angles, starting and closing on an observed azimuth. If the compass must be relied on a meridian line should be established and the local declination determined in order to locate courses accurately with reference to the true north.

In view of the above, it has been considered to be of sufficient importance to publish herewith tables relating to the times of the culminations and elongations of Polaris and to the azimuths of Polaris at elongation. An example is given of the application of these tables and also a set of simple instructions for the determination of a true meridian as well as the local declination.

There are many more elaborate methods for determining azimuths, some of which were used in connection with the establishment of the meridian marks in West Virginia. These methods are fully set forth in the Manual of Topographic Methods published by the U. S. Geological Survey and the Manual of Instructions issued by the U. S. General Land Office. Much of the information herein has been taken from the latter publication.

The following table gives the approximate local mean (astronomical) times of the Culminations and Elongations of Polaris in the year 1898:

(Astronomical time is counted from noon and from 0 to 24 hours.)

Date.	East Elongation.		Upper Culmination.		West Elongation.		Lower Culmination.	
1898.	hr.	min.	hr.	min.	hr.	min.	hr.	min.
January 1	0	39.3	6	34.1	12	28.9	18	32.1
" 15	23	40.1	5	38.8	11	33.6	17	36.8
Febru'y 1	22	32.9	4	31.7	10	26.5	16	29.7
" 15	21	37.7	3	36.4	9	31.3	15	34.4
March 1	20	42.5	2	41.2	8	36.0	14	39.2
" 15	19	47.4	1	46.1	7	40.9	13	44.2
April 1	18	40.4	0	39.1	6	33.9	12	37.2
" 15	17	45.4	23	40.2	5	38.9	11	42.2
May 1	16	42.6	22	37.3	4	36.1	10	39.3
" 15	15	47.7	21	42.4	3	41.2	9	44.4
June 1	14	41.0	20	35.8	2	34.5	8	37.8
" 15	13	46.1	19	40.9	1	39.6	7	42.9
July 1	12	43.5	18	38.3	0	37.0	6	40.3
" 15	11	48.6	17	43.4	23	38.2	5	45.4
August 1	10	42.1	16	36.9	22	31.7	4	38.9
" 15	9	47.2	15	42.0	21	36.8	3	44.0
Sept'r 1	8	40.6	14	35.4	20	30.2	2	37.4
" 15	7	45.7	13	40.5	19	35.3	1	42.5
October 1	6	42.9	12	37.7	18	32.5	0	39.7
" 15	5	47.9	11	42.7	17	37.5	23	40.8
Nov'b'r 1	4	41.1	10	35.9	16	30.7	22	33.9
" 15	3	45.9	9	40.7	15	35.5	21	38.7
Dec'b'r 1	2	42.9	8	37.7	14	32.5	20	35.7
" 15	1	47.6	7	42.4	13	37.2	19	40.4

To refer to any calendar day other than the first and fifteenth of each month, subtract 3.94 m. for every day between it and the preceding tabular day, or add 3.94 m. for every day between it and the succeeding tabular day.

It will be noticed that for the tabular year two eastern elongations occur on Jannary 10, and two western elongations on July 9; there are also two upper culminations on April 10, and two lower culminations on October 10.

The lower culmination either follows or precedes the upper culminations at an interval of 11 h. 58 m. Also east elongation either follows west elongation at an interval of 12 h. 06.5 m., or precedes it at an interval of 11 h. 49.6 m.

To refer the tabular times to any year subsequent to the year 1898, add 0.2 m. (nearly) for every additional year.

Azimuths of Polaris when at elongation for any year between 1898 and 1910, and for any latitude between 37° and 41° north. The tabular table numbers apply more particularly to the middle of April and the middle of September for each year.

Latitude	1898	1899	1900	1901	1902	1903
37	1°32′.9	1°32′.5	1°32′.1	1°31′.7	1°31′.3	1°30′.9
38	1 34 .2	1 33 .8	1 33 .4	1 33 .0	1 32 .6	1 32 .2
39	1 35 .5	1 35 .1	1 34 .7	1 34 .3	1 33 .9	1 33 .5
40	1 36 .8	1 36 .4	1 36 .0	1 35 .6	1 35 .2	1 34 .8
41	1 38 .3	1 37 .9	1 37 .5	1 37 .1	1 36 .7	1 36 .2

Latitude	1904	1905	1906	1907	1908	1909	1910
37	1°30′.5	1°30′.1	1°29′.7	1°29′.3	1°29′.0	1°28′.6	1°28′.2
38	1 31 .8	1 31 .4	1 31 .0	1 30 .6	1 30 .2	1 29 .8	1 29 .4
39	1 33 .1	1 32 .7	1 32 .3	1 31 .8	1 31 .4	1 31 .0	1 30 .6
40	1 34 .4	1 34 .0	1 33 .6	1 33 .2	1 32 .8	1 32 .4	1 32 .0
41	1 35 .8	1 35 .4	1 35 .0	1 34 .6	1 34 .2	1 33 .8	1 33 .4

The preceding table was computed with the mean place (declination) of Polaris for each year. A closer result will be had by applying to the tabular results the following correction, which depends upon the difference of the mean and the apparent declinations of the star.

Corrections of Azimuths from Polaris Observations for each month.

For middle of	Latitude. 40°	55°	For middle of	Latitude. 40°	55°
January,	−0′.4	−0′.5	July,	+0′.3	+0′.4
February,	−0 .3	−0 .4	August,	+0 .1	+0 .2
March	−0 .2	−0 .2	September,	−0 .1	−0 .1
April,	0 .0	0 .0	October,	−0 .3	−0 .4
May,	+0 .2	+0 .2	November,	−0 .6	−0 .7
June,	+0 .3	+0 .4	December,	−0 .8	−0 .9

Example of application of tables for the determination of time of elongation and corresponding azimuth of Polaris:

Charlestown, West Virginia, June 7, 1898, A. M.

Latitude, 39°17′ Longitude, 77°51′

Astronomical time of eastern elongation June 1, 1898,	-	14h 41m	.1
Reduction to June 6, 3m .94 x 5,	—	19	.7
Time of eastern elongation June 6, afternoon,	- -	14 21	.4
Corresponding to civil date June 7,		2 21	.4 A. M.
Reduction to 75th Meridian or			

standard watch time, - + 11 .2

June 7, 1898, standard or watch time, - - - - 2h 32m .6 A. M.

From the azimuth table it is found that the star at elongation is 1°36′ to the east of the true meridian.

INSTRUCTIONS FOR DETERMINING A TRUE MERIDIAN BY OBSERVATIONS ON POLARIS AT ELONGATION WITH A TRANSIT.

1. Set a stone, or drive a wooden plug, firmly in the ground, and upon the top thereof make a small distinct mark.

2. About thirty minutes before the time of the eastern or western elongation of Polaris, as given by the tables of elongation, set up the transit firmly, with its vertical axis exactly over the mark, and carefully level the instrument.

3. Illuminate the cross wires by the light from a bull's-eye lantern or other source, the rays being directed into the object end of the telescope by an assistant; while great care will be taken to see that the line of collimation describes a truly vertical plane.

4. Place the vertical wire upon the star, which, if it has not reached its elongation, will move to the right for eastern, and to the left for western elongation.

5. While the star moves towards its point of elongation, by means of the tangent screw of the vernier plate it will be continually covered by the vertical wire, until a point is reached where it will appear to remain on the wire for some time, then leave it in a direction contrary to its former motion; thus indicating the point of elongation.

6. At the instant the star appears to thread the vertical wire, depress the telescope to a horizontal position; about 500 feet north of the place of observation, set a stone or drive a wooden plug, upon which by a strongly illuminated pencil or other slender object, exactly coincident with the vertical wire, mark a point in the line of sight thus determined; then *quickly* revolve the vernier plate 180°, repeat the observation, and as before mark a point in the new direction; then, the middle point between the two marks, with the point under the instrument, will define on the ground the trace of the vertical plane through Polaris at its eastern or western elongation, as the case may be.

7. If the local time is accurately known it will not be necessary to follow the star with the wire, but it will be sufficient to make a set of observations extending through a period of about ten minutes before and ten minutes after elongation, the mean result being accepted.

8. By daylight, lay off to the east or west, as the case may require, the proper azimuth taken from the table on page 62; the instrument will then define the *true meridian*, which may be permanently marked by monuments for future reference.

9. The magnetic declination may be obtained from a true meridian, as follows: Take the magnetic bearing of the true meridian; then the angle expressed by said magnetic bearing will be the observed magnetic declination, named like the departure if the bearing is taken from the south, but the reverse if taken from the north.

DETAILED DESCRIPTION OF THE MERIDIAN MONUMENTS AND THEIR LOCATION IN THE DIFFERENT COUNTIES.

BARBOUR COUNTY.

PHILIPPI.

Location: In south part of town on a street running nearly east and west on land now owned by C. A. W. Smith; in third lot west from Main street and where the curve on the north side of the street will fall.

Station Mark: Heavy sandstone column in center of which is a copper bolt.

Distant Mark: South of station about 2,000 feet; in N. W. corner of lot owned by Hon. A. G. Dayton. This mark is similar to one at north station.

Resident Referee: T. L. O'Neal, County Surveyor.

Magnetic Declination: 3° 27′ W, July 27, 1898. Mean annual change +03′, approximately.

BERKELEY COUNTY.

MARTINSBURG.

Location: At head of principal drive of cemetery and 13 feet west of walk.

Station Mark: A column of marble 40″ × 8″ × 6″; set 32″ in ground, in the center of which is a copper plate.

Distant Mark: North of station 575 feet. It is a marble column 40″ × 8″ × 6″; set 32″ in ground, 30 feet east of the entrance gate and 4 feet from the fence. Aluminum bolt in center of stone.

Resident Referee: J. L. Bender, County Clerk.

Magnetic Declination: 4° 27′ W., May 27, 1898. Mean annual change, +03′, approximately.

BOONE COUNTY.

MADISON.

Location: On hillside N. E. of Methodist Church on land owned by Mr. Thompson.

Station Mark: Column of sandstone 42″ × 8″ × 8″; set 36″ in ground, in center of which is a copper plate.

Reference Mark: Cherry tree 2″ in diameter, N. 88° E. 96 feet; hickory tree 11″ in diameter, S. 70° E., 148 feet; N. E. corner of M. E. Church, S. 85° W., 315 feet.

Distant Marks: North of station 237.8 feet. It is a sandstone column 30″ × 8″ × 8″; set 30″ in ground, 1 foot south of south fence of St. Clair Hotel. Aluminum bolt in center of stone.

Reference Marks: N. E. corner of M. E. Church, S. 40° W., 520.7 feet; S. W. corner of St. Clair Hotel, N. 10° E., 93.6 feet; S. E. corner Leftwitch's house, N. 70° W., 91.8 feet.

Resident Refere: J. M. Hupton, County Clerk.

Magnetic Declination: 20° 11′ W., 9:00 a. m., August 29, 1898. Mean annual change +03′, approximately.

BRAXTON COUNTY.

SUTTON.

Location: On east side of Main street at corner of first street north of the bluff in Upper Sutton.

Station Mark: Sandstone post in center of which is a copper station mark.

Distant Mark: North of station 843.2 feet, on same side of Main street and is on north side of second street north of station. Mark similar to that at station.

Resident Refere: Mr. John B. Dunlop and Mr. James A. Johnson, Surveyors, assisted in setting the stones.

Magnetic Declination: 2° 16′ West, June 29, 1898. Mean annual change +03′, approximately.

BROOKE COUNTY.

WELLSBURG.

Location: In south-west corner of proposed public square.

Station Mark: A column of Ohio sandstone 42″ × 8″ × 8″; set 36″ in ground; in the center of which is a copper plate.

Reference Marks: Small maple at south-west corner of the square, 19 feet; small maple on the west line of square, 29 feet; it is 4.9 feet north of the south line of square; 17.5 feet east of the west line of square.

Distant Mark: North of station 343.3 feet. It is a sandstone column 44″ × 8″ × 8″; set 38″ in ground near curb line of proposed 17th street. Aluminum bolt in center of stone. Reference marks of same: West line of street, 51 feet; maple 5″ in diameter, S. 45° W., 67 feet; maple 4″ in diameter, S. 68° W., 117 feet.

Resident Referee: G. W. McCord, County Clerk.

Magnetic Declination: 1° 34′ West, 11:20 a. m. December 14, 1898. Mean annual change, +03′, approximately.

CABELL COUNTY.

HUNTINGTON.

Location: Near south-west corner of new unfinished school building, situated on south-east corner of Fifth avenue and Sixth street.

Station Mark: A free stone buried with top 2 feet below surface of ground, in center of which is a copper bolt.

Distant Mark: South of station mark 1,000 feet, in a field beyond which is an orchard. This mark is similar to that at the north.

Resident Referee: J. H. Sandborn, City Engineer and Surveyor, witnessed the setting of both marks.

Magnetic Declination: 0° 51′ W., May 31, 1898. Mean annual change +03′, approximately.

CALHOUN COUNTY.

GRANTSVILLE.

Location: In ground owned by J. G. S. Smith; south of Baptist Church on a steep hillside.

Station Mark: A column of sandstone 44″ × 8″ × 8″; set 30″ in ground, in center of which is a copper plate.

Reference Marks: Walnut tree 14″ in diameter, N. 74° E., 149 feet; walnut tree 5″ in diameter, N. 22° W., 48 feet; beech tree, S. 40° W., 148.6 feet.

Distant Mark: North of station 370 feet. It is a sandstone column 30″ × 8″ × 8″; set in ground on fence line 9 feet south of south-west corner of Baptist church. Aluminum bolt in center of stone. Reference marks of same: South-east corner of Baptist church, N. 40° E., 48 feet; southwest corner of Baptist church, N. 65° W., 19.5 feet; walnut tree 12″ in diameter, S. 55° W., 112 feet.

Resident Referee: L. H. Trippett, County Clerk.

Magnetic Declination: 1° 15′W., 10.00 a. m. July 22, 1898. Mean annual change, +03′, approximately.

CLAY COUNTY.

CLAY.

Location: Corner of Main and third alley.

Station Mark: A column of sandstone 42″ × 8″ × 8″; set 36″ in ground, in center of which is a copper plate.

Reference Marks: South-west corner of Main street and third alley, N. 88° W., 33.4 feet; North-west corner of Main street and third alley, N. 10° W., 62.7 feet; N. E. corner of Main street and third alley, N. 20° E., 52.9 feet; S. E. corner Main street and third alley, East 5.7 feet.

Distant Mark: North of station 365.2 feet. It is a sandstone column 36″ × 8″ × 8″ set 36 inches in ground west of Baptist church, and along east fence to Davenport's yard. Aluminum bolt in center of stone. Reference marks for same: south-west corner of Baptist church, S. 75° E., 73 feet; north-west corner of Baptist church, N. 60° E., 83.5 feet; south-east corner of Davenport's house, N. 15° W., 46.2 feet.

Resident Referee: W. T. Hamerick, County Clerk.

Magnetic Declination: 1° 21′ W, 10.45 a. m. November 12, 1898. Mean annual change, +03′, approximately.

DODDRIDGE COUNTY.

West Union.

Location: In public school grounds, 4.7 feet north of fence along south of grounds.

Station Mark: Sandstone column 45″ × 8″ × 8″; set 39″ in ground, in center of which is a copper plate.

Reference Marks: Maple tree 4″ in diameter, S. 85° W. 5.5 feet; southwest corner of school building, N. 50° E., 160 feet; south-east corner of school building, N. 29° E., 169 feet.

Distant Mark: North of station 303.5 feet. It is a sandstone column 35″ × 8″ × 8″; set 35″ in ground in N. W. corner of public school ground, 12 feet S. of north fence of ground. Aluminum bolt in center of stone. Reference marks of same; N. W. corner of school building, S. 22° E., 72 feet; locust tree 8″ in diameter, N. 40° W., 18.5 feet; maple tree 4″ in diameter, N. 50′ E., 34 feet.

Resident Referee: County Surveyor.

Magnetic Declination: 2° 20′ W, 10:30 a. m. July 12, 1898. Mean annual change, +03′, approximately.

FAYETTE COUNTY.

FAYETTEVILLE.

Location: On Maple avenue on south side of street between first and second alley.

Station Mark: Column of sandstone 42″ × 8″× 8″; set 36″ in ground, in the center of which is a copper plate.

Reference Marks: S. E. corner of Trimble's livery, N. 80° W., 125.4 feet; corner of Maple avenue and second alley, S. 80° E., 128.6 feet; N. E. corner of Journal Printing Office, S. 58° W., 206 feet.

Distant Mark: North of station 428 feet. It is a column of sandstone 36″ × 8″ × 8″; set 36″ in ground in north side of lot owned by J. F. White near fence line and about 50 feet E. of old fort. Aluminum bolt in center of stone. Reference marks of same: N. E. corner of lot, N. 30° E., 21.8 feet; N. W. corner of carriage house, S. 25° E., 54.6 feet; north fence of lot is two feet north of stone.

Resident Referee: J. T. Grose, County Clerk.

Magnetic Declination: 1° 28′ W., 10:00 a. m., November 8, 1898. Mean annual change +03′, approximately.

GILMER COUNTY.

GLENVILLE.

Location: In Normal School grounds, 26.8 feet S. E. of south-east corner of school building.

Station Mark: Column of sandstone 42″ × 8″ × 8″; set 36″ in ground, in center of which is a copper plate.

Reference Marks: South-east corner of building, N. 40° W., 26.8 feet; southwest corner of building, N. 83° W., 49.8 feet; apple tree 8″ in diameter, N. 10° E., 95 feet.

Distant Mark: North of station 304 feet. It is a sandstone column 30″ × 8″ × 8″; set 30″ in ground owned by George E. Linn; on fence line 14 feet west of the N. E. corner of Normal School grounds. Aluminum bolt in center. Reference marks of same: Oak tree 22″ in diameter, S. 80° E., 22 feet; apple tree 5″ in diameter, N. 22° E., 36 feet; Northeast corner of building S. 33° W., 105 feet.

Resident Referee: J. N. Kee, County Clerk.

Magnetic Declination: 2° 8′ W., 10:00 a. m., July 17, 1898. Mean annual change, +03′, approximately.

GRANT COUNTY.

PETERSBURG.

Location: Northwest corner of court house yard; 821 feet north of line of fence E. and W.

Station Mark: Column of sandstone 44″ × 10″ × 7″; set 40″ in ground, in center of which is a copper plate.

Reference Marks: Northwest corner of Main building of court-house, S. 86° E., 62 feet; North-west corner of a wing to court-house, S. 18° E., 51 feet; south-west corner of wing to court-house, S. 40° E. 70 feet.

Distant Mark: North of station 821 feet. It is a sandstone column 28″ × 8″ × 8″; set 28″ in ground near an east and west line of fence. Aluminum bolt in center of stone. Reference marks of same: Line fence 3 feet long; water oak tree 7″ in diameter, S. 80° E., 178 feet.

Resident Referee: D. E. Hendrickson County Clerk.

Magnetic Declination: 3° 37′ W, June 14, 1898. Mean annual change, +03′, approximately.

GREENBRIER COUNTY.

LEWISBURG.

Location: In the grounds of Major Lee's Military Academy, east of main building.

Station Mark: A column of sandstone 42″ × 8″ × 8″; set 36″ in ground, in center of which is a copper plate.

Reference Marks: Oak tree 30″ in diameter, South, 12.1 feet; N. E. corner of school building, S. 75° W., 76. feet; cherry tree 8″ in diameter, N. 78° W., 90.8 feet.

Distant Mark: North of station 323 feet. It is a column of sandstone 36″ × 8″ × 8″; set 36″ in ground in north-east corner of school yard. Aluminum bolt in center of stone. Reference marks of same: maple tree 18″ in diameter, S. 75° W., 65.3 feet; frame house N. 10° E., 162 feet. It is 6 feet west of corner post.

Resident Refere: Charles E. Buster, County Clerk.

Magnetic Declination: 1° 41′ W, 10:00 a. m. October 22, 1898. Mean annual change +03′, approximately.

HAMPSHIRE COUNTY.

ROMNEY.

Location: In grounds of Deaf, Dumb and Blind Institution, north of the main building in S. E. corner of base ball ground.

Station Mark: A column of marble 42″ × 7″ × 7″; set 36″ in ground in center of which is a copper plate.

Reference Marks: North-east corner of square brick building S. 52° E., 92 feet; North-west corner of square brick building, S. 34° E., 45.5 feet; North-east corner of Deaf and Dumb sitting room, S. 11° W., 39.5 feet; Northwest corner of Deaf and Dumb sitting room S. 67° W., 54 feet.

Distant Mark: North of station, 645 feet. It is a limestone column 30″ × 10″ × 6″; set 28″ in ground on the line of the fence, 21 feet E. of the fence running north. Aluminum bolt in center of stone.

Resident Referee: C. S. White, County Clerk.

Magnetic Declination: 2° 46′ W., June 10, 1898. Mean annual change, +03′, approximately.

HANCOCK COUNTY.

NEW CUMBERLAND.

Location: In back yard of public school grounds.

Station Mark: A column of sandstone 42″ × 10″ × 10″; set 36″ in ground, in the center of which is a copper plate.

Reference Marks: South-east corner of school house chimney, N. 65° W., 16.5 feet; south-west corner of school house chimney, N. 73° W., 20.8 feet; south-east corner of school house, S. 33° W. 19.6 feet.

Distant Mark: North of station 631.5 feet. It is a sandstone column 36″ × 10″ × 10″; set 36″ in ground at the south-east corner of blacksmith's shop on highway north of school house. Aluminum bolt in center of stone. Reference marks of same: South-east corner of blacksmith's shop 2.3 feet; south-west corner of blacksmith's shop 13 feet.

Resident Referee: Clerk of Circuit Court.

Magnetic Declination: 1° 38′ W., 3:00 p. m. December 15, 1898. Mean annual change +03′, approximately.

HARDY COUNTY.

MOOREFIELD.

Location: About one-half mile east of town on top of hill on land owned by J. W. Gilkeson. About 150 feet north of road and on line of fence which bears N. 14° E., and S. 14° W.

Station Mark: A column of marble 44″ × 7″ × 7″; set 37″ in ground, in the center of which is a copper plate.

Reference Marks: Oak tree 18″ in diameter, N. 54° W., 450 feet; oak tree 8″ in diameter, S. 3° E. 160 feet.

Distant Mark: North of station 826 feet. It is a column of marble 33″ × 7″ × 7″; set 30″ in ground, 3 feet south of south fence of cemetery. Aluminum bolt in center of stone. Reference marks of same: Monument to G. P. Williams N. 60° E., 26.5 feet; monument to J. R. Heiskill N. 10° E. 16.5 feet.

Resident Referee: C. Wilton, County Clerk.

Magnetic Declination: 3° 37′ W., June 18, 1898. Mean annual change +03′, approximately.

HARRISON COUNTY.

CLARKSBURG.

Location: In public school gronnds, 170 feet east of public school building.

Station Mark: Very fine sandstone post, in center of which is a copper station mark.

Distant Mark: North of station 735 feet. On the opposite side of valley of Elk creek near bridge crossing on B. & O. R. R. tracks.

Resident Referee: J. H. Davis, Civil Engineer. North stone was set under his direction.

Magnetic Declination: 2° 50′ W., June 25, 1898. Mean annual change +03′, approximately.

JACKSON COUNTY.

RIPLEY.

Location: In south-west corner of court house grounds.

Station Mark: Sandstone column 42″ × 8″ × 8″; set 36″ in ground in south-west corner of court house grounds. Copper plate in center of stone.

Reference Marks: South-east corner of Hassler Hotel, S. 73° W., 111.3 feet; south-west corner of Clerk's office, N. 74° E. 158.8 feet: southwest corner of court house, N. 44° E., 194.2 feet.

Distant Mark: North of station 334.5 feet. It is a sandstone column 36″ × 8″ × 8″; set 36″ in ground, near north-west corner of court house grounds. Aluminum bolt in center of stone. Reference marks of same: North-west corner of court-house S. 2° W., 224.2 feet; J. M. Wright's house North 46 feet.

Resident Referee: G. B. Crow, County Clerk.

Magnetic Declination: 1° 25′ W., 10:30 a. m., November 25, 1898. Mean annual change +03′, approximately.

JEFFERSON COUNTY.

CHARLESTOWN.

Location: In corner of wall at north-east corner of M. E. Church.

Station Mark: A column of sandstone 40″ × 10″ × 7″; set 36″ in ground, in the center of which is a copper plate.

Reference Marks: East wall of church 4.9 feet; south wall of church 10 feet; north corner of church 8.9 feet; north-east corner 10.3 feet.

Distant Mark: North of station 767 feet. It is a column of limestone 30″ × 10″ × 7″; set 28″ in ground. Aluminum bolt in center of stone. Reference marks of same: South-east corner of Harness Factory. S., 60° E., 76.5 feet.

Resident Referee: County Surveyor.

Magnetic Declination: 3° 32′ W., June 6, 1898. Mean annual change +03′, approximately.

KANAWHA COUNTY.

CHARLESTON.

Location: On Capitol Hill on property of J. S. Savage, 140 feet above general surface of the ground.

Meridian Marks: Three stone columns determine the meridian. One is a sandstone set 75.25 feet south of station in the lawn about Mr. Savage's house. In the center of stone is a copper bolt. One is a sandstone on side of hill about 1.5 miles south of station; copper bolt in center of stone.

Resident Referees: Judge John S. McDonald of County Court, and Wm. S. Brown, County Surveyor.

Magnetic Declination: 1° 57′ W., June 8,1898. Mean annual change +03′, approximately.

LEWIS COUNTY.

WESTON.

Location: In the grounds of the West Virginia Hospital for Insane, in front of south wing of main building.

Station Mark: Blue sandstone column, in center of which is a copper station mark.

Distant Mark: North of station 302 feet. It is a sandstone column in front and a little south of the main building. Copper station mark in center of stone.

Magnetic Declination: 2° 31′ W., July 6, 1898. Mean annual change +03′, approximately.

LINCOLN COUNTY.

HAMLIN.

Location: On Main street, opposite James Brown's house.

Station Mark. A column of sandstone 43″ × 8″ × 8″; set 36″ in ground, in the center of which is a copper plate.

Reference Marks: South-east corner of H. Eaststep's house, N., 46° W., 78.2 feet; north-west corner of James Brown's house N. 80° E., 39 feet; south-west corner of James Brown's house S. 30° E., 42 feet.

Distant Mark: North of station 304 feet. It is a sandstone column 35″ × 8″ × 8″; set 35″ in ground, opposite Dr. Thacker's house and near his porch. Aluminum bolt in center of stone. Reference marks of same: South-east corner of Dr. Thacker's house, N. 65° W., 6 feet; south-west corner of Dr. Thacker's porch, N. 50° E., 9.5 feet.

Resident Referee: Robert Hager, County Clerk.

Magnetic Declination: 1° 32′ W., 9:40 a. m., November 15, 1898. Mean annual change, +03′, approximately.

LOGAN COUNTY.

LOGAN.

Location: In court house grounds, 8 feet east of north-east corner of court house.

Station Mark: A column of red sandstone, 42″ × 8″ × 8″; set 36″ in ground, in the center of which is a copper plate.

Reference Marks: North-east corner of court house, N. 85° W., 8 feet; locust tree 5″ in diameter, S. 5° E. 18 feet; locust tree 6″ in diameter, N. 10° E. 39 feet.

Distant Mark: North of station 712 feet. It is a sandstone column 30″ × 8″ × 8″; set 30″ in ground, 5 feet east of east fence of cemetery. Aluminum bolt in center of stone. Reference marks of same: Walnut tree 18″ in diameter, S. 14° W., 180.8 feet; elm tree 14″ in diameter, S. 85° E. 97.8 ft; cherry tree in cemetery, 24″ in diameter, S. 75° W., 84.5 feet.

Resident Referee: S. S. Altizer, County Clerk.

Magnetic Declination; 1° 31′ W., 11:00 a. m., August 31, 1898. Mean annual change +03′, approximately.

McDOWELL COUNTY.

WELCH.

Location: In court house grounds, in north-east corner of court house.

Station Mark: A column of sandstone 42″ × 8″ × 8″; set 36 in ground, in center of which is a copper plate.

Reference Marks: Southwest corner of jail, N. 42° E., 48.8 feet; north-east corner of court house, 5.4 feet; north-east angle of court house, 15.2 feet; second north-east corner of court-house, 14.5 feet; third north-east corner of court house, 33.3 feet.

Distant Mark: North of station 375.1 feet. It is a sandstone column 38″ × 8″ × 8″; set 38″ in ground on hillside north of court house; aluminum bolt in center of stone. Reference marks of same: Small house, S. 40° E., 51 feet; small white house S. 35° W., 126 feet.

Resident Referee: R. B. Bernheim, County Clerk.

Magnetic Declination: 1° 48′ W., 10:45 a. m., October 31, 1898. Mean annual change, +03′, approximately.

MARION COUNTY.

FAIRMONT.

Location: Mound in north-east corner of Normal School yard.

Station Mark: A column of sandstone 44″ × 8″ × 8″; set 36″ in ground, in the center of which is a copper plate.

Reference Marks: Sycamore tree 10″ in diameter, S. 25° W., 12 feet; north-east steps of Normal School building, S. 35° E., 55 feet; north-east corner of Normal School lot, N. 5° W., 75 feet.

Distant Mark: North of station, 2,404 feet. It is a sandstone column 30″ × 8″ × 8″; set 30″ in ground. Aluminum bolt in center of stone. It is 40 feet west of street running north-west on hillside across ravine.

Resident Referee: T. L. Burchinal, County Commissioner.

Magnetic Declination: 3° 21′ W., July 4, 1898. Mean annual change, +03′, approximately.

MARSHALL COUNTY.

MOUNDSVILLE.

Location: North-east corner of Eighth and Tomlinson streets, along curb line, 80 feet south-west of corner of public school building, 200 feet north of Great Mound.

Station Mark: A column of Ohio sandstone 42″ × 8″ × 8′; set 36″ in ground, in center of which is a copper plate.

Reference Marks: To south-west corner of school building, 18.3 feet; north-east curbstone Eighth and Tomlinson streets, 12.8 feet; north-west corner of same, 38.1 feet; south-west corner of same, 64.6 feet.

Distant Mark: North of station 959.2 feet. It is a sandstone column similar to station mark, set in ground near north-west corner of Sixth and Tomlinson streets. Aluminum bolt in center of stone. Reference marks of same: north-east corner of Sixth and Tomlinson streets, 55.6 feet; south corner of W. D. Alexander's house; 40.9 feet; maple 2 feet in diameter, N 9.2 feet.

Resident Referee: E. M. Lewis, County Clerk.

Magnetic Declination: 1° 07′ W.,10:30 a.m., December, 10, 1898. Mean annual change, +03′, approximately.

MASON COUNTY.

Point Pleasant.

Location: In the grounds of the High School.

Station Mark: Column of sandstone 42″ × 8″ × 8″; set 36″ in ground, in the center of which is a copper plate.

Reference Marks: South-east corner of school building, N. 46° W., 125.2 feet; north-east corner of school building, N 23° W., 179.5 feet; north-east corner of school grounds N. 15° E., 180.5 feet.

Distant Mark: North of station, 337.6 feet. It is a sandstone column 36″ × 8″ × 8″; set 36″ in ground, in the jail yard. Aluminum bolt in center of stone. Reference marks of same: North-west corner of jail, N. 80° E., 25.8 feet; south-west corner of jail, S. 10° W. 61.6 feet.

Resident Referee: J. P. R. B. Smith, County Clerk.

Magnetic Declination: 1° 21′ W., 10:00 a. m., November 21, 1898. Mean annual change +03′, approximately.

MERCER COUNTY.

PRINCETON.

Location: In High School grounds, 3.5 feet north of south fence.

Station Mark: A column of sandstone, 42″ × 10″ × 10″; set 36″ in ground, in the center of which is a copper plate.

Reference Marks: South-east corner of High School building, N. 38° W., 223.5 feet; maple tree 4″ in diamter, N. 45° E., 140.9 feet; south-east corner of High School grounds, East 70.8 feet.

Distant Mark: North of station 385 feet. It is a column of sandstone 36″ × 8″ × 8″; set in ground 36″, 3.4 feet south of the north fence of High School ground. Aluminum bolt in center of stone. Reference marks of same: pine tree 24″ in diameter, S. 10° W., 38 feet; oak tree 5″ in diameter, S. 10° E., 33 feet.

Resident Referee: A. J. Hearn, County Clerk.

Magnetic Declination: 1° 33′ W., 11:00 a. m., October 28, 1898. Mean annual change, +03′, approximately.

MINERAL COUNTY.

KEYSER.

Location: On the south-east side of field near public road, and 3 feet west of east fence.

Station Mark: A column of marble 44″ × 7″ × 7″; set 38″ in ground, in center of which is a copper plate.

Reference Marks: To elm tree 26″ in diameter, S. 29° W., 166 feet; cupola on school house bears N. 16° E.; pinnacle S., 55° W.

Distant Mark: North of station, 1,040.3 feet. It is a column of marble 36″ × 7″ × 7″; set 36″ in ground near the north-west corner of field near intersection of street and alley and 3 feet east of street fence. Aluminum bolt in center of stone. Reference marks of same: South-east corner of yard on alley, N. 64° W., 49 feet; south-west corner of yard, N. 32° E., 20 feet.

Resident Referee: J. V. Bell, County Clerk.

Magnetic Declination: 3° 57′ W., June 21, 1898. Mean annual change +03′, approximately.

MINGO COUNTY.

WILLIAMSON.

Location: Corner of Second avenue and Third alley.

Station Mark: A column of sandstone 42″ × 8″ × 8″; set 36″ in ground, in center of which is a copper plate.

Reference Marks: South fence of Third alley, 7.3 feet; west fence of Second avenue. 4.3 feet; south-east corner of house on the north-west corner of street, N., 60° E., 59.4 feet.

Distant Mark: North of station 812.2 feet. It is a sandstone column. 36″ × 8″ × 8″; set 36″ in ground on hillside across ravine at the edge of the timber. Aluminum bolt in center of stone. Reference marks of same: oak tree, 36″ in diameter, N. 5° W., 79.5 feet; cherry tree 14″ in diameter, N. 84° E., 60 feet; oak tree 5″ in diameter, N. 88° W., 58 feet.

Resident Referee: James A. Chafin, County Clerk.

Magnetic Declination: 1° 42′ W., 10:00 a. m., November 4, 1898. Mean annual change +03′, approximately.

MONONGALIA COUNTY.

MORGANTOWN.

Location: South side State University grounds; 11 feet north of south fence.

Station Mark: Sandstone column 44″ × 8″ × 8″; set 36″ in ground, in center of which a copper plate is placed.

Reference Marks: Maple tree 14″ in diameter, N. 75° E., 59 feet; sycamore tree, 25″ in diameter, N. 35° W., 236 feet; small frame house, S. 45° W., 16 feet; small frame house, S. 55° E., 25 feet.

Distant Mark: North of station, 460 feet. Sandstone column 30″ × 8″ × 8″; set 30″ in ground in University Park. Aluminum bolt in center of stone. Reference marks of same: north-west corner of Law Building, east, 60 feet; pine tree, 8″ in diameter, N. 10° W., 20 feet.

Resident Referee: John E. Price, County Clerk.

Magnetic Declination: 3° 21′ W., June 30, 1898. Mean annual change, +03′, approximately.

LIBRARY OF THE UNIVERSITY OF CALIFORNIA

MONROE COUNTY.

UNION.

Location: On the west side of Main street opposite the Post Office.

Station Mark: A column of limestone 42″ × 8″ × 8″; set 36″ in ground in the center of which is a copper plate.

Reference Marks: North-east corner of Mrs. M. Dunlap's house, S. 45° W., 40.8 feet; south-west corner of post-office, N. 65° E., 66.6 feet; southwest corner of court house, N. 30° E., 155.7 feet.

Distant Mark: North of station 634.7 feet. It is a limestone column 36″ × 8″ × 8″; set 36″ in ground on the east side of Main street, north of corner of Bryan and Main streets. Aluminum bolt in center of stone. Reference marks of same: Sycamore tree 24″ in diameter, S. 62° W., 62.7 feet; white house on south-east corner of Bryan and Main streets, S. 75° W., 33.5 feet.

Resident Referee: J. M. McClaugherty, County Clerk.

Magnetic Declination: 1° 43′ W., 10:30 a. m., October 25, 1898. Mean annual change, +03′, approximately.

MORGAN COUNTY.

Berkeley Springs.

Location: State land adjoining the Berkeley Springs Hotel.

Station Mark: A column of limestone 36″ × 6″ × 6″; set 30″ in ground, 12 feet from fence on north-east side of ground.

Reference Mark: "Washington Elm," N. 20° E., 18 feet.

Distant Mark: North stone, limestone 6″ × 6″ × 36″; set 30″ in ground 300 feet north of south stone, and 14 feet west of iron gate.

Magnetic Declination: 4° 36′ W., November 21, 1897. Mean annual change, +03′, approximately.

NICHOLAS COUNTY.

SUMMERSVILLE.

Location: In public school grounds, 10 feet north of south fence.

Station Mark: A column of sandstone 42″ × 8″ × 8″; set 36″ in ground, in center of which is a copper plate.

Reference Marks: Maple tree 3″ in diameter, West 15.6 feet; wild cherry tree 26″ in diameter, N. 64° E., 217.5 feet; south-west corner of school house, N. 78° E., 287.2 feet.

Distant Mark: North of station 851.5 feet. It is a column of sandstone 30″ × 8″ × 8″; set 30″ in ground in land owned by A. Muerin, near fence line. Aluminum bolt in center of stone. Reference marks of same: Locust tree 8″ in diameter, N. 55° W., 119.5 feet; locust tree 13″ in diameter, N. 14° E., 152.7 feet; cherry tree, 7″ in diameter, S. 57° W., 47 feet.

Resident Referee: J. A. Hamilton, County Clerk.

Magnetic Declination: 3° 14′ W., 9:45 a. m., August 25, 1898. Mean annual change +03′, approximately.

OHIO COUNTY.

WHEELING.

Location: On State Fair Grounds, inside the race course and near to the north-west side of race course.

Station Mark: A Cleveland sandstone post, in the center of which is a new copper station mark.

Distant Mark: South of station between 450 and 500 feet. Inside the race course is a sandstone column similar to one at the station, in the center of which is a copper bolt.

Resident Referee: Robert Hazlett, Chief Engineer.

Magnetic Declination: 1° 01′ W., July 21, 1898. Mean annual change, +03′, approximately.

PENDLETON COUNTY.

FRANKLIN.

Location: East of town, about 800 feet in south side of meadow owned by W. H. Boggs.

Station Mark: A column of limestone 44″ × 7″ × 7″; set 38″ in ground, in center of which is a copper plate.

Reference Marks: South-east corner of field, S. 10° E., 6 feet; apple tree N. 86° E., 24.5 feet; locust tree 7″ in diameter, N. 8° W., 308 feet.

Distant Mark: North of station 419 feet. It is a column of limestone 44″ × 7″ × 7″; set 36″ in ground on the north side of same meadow. Aluminum bolt in center of stone. Reference marks of same: Locust tree, S. 20° W., 121 feet; where fence joins alley, N. 69° W. 262 feet.

Resident Referee: I. E. Bolton, County Clerk.

Magnetic Declination: 2° 43′ W,, June 18, 1898. Mean annual change, +03′, approximately.

PLEASANTS COUNTY.

St. Marys.

Location: In the court-house yard in front of the main entrance to court-house.

Station Mark: A column of sandstone 42″ × 10″ × 10″; set 36″ in the ground, in the center of which is a copper plate.

Reference Marks: North-west corner of court-house, S. 11° W., 55.8 feet; north-east corner of court-house, S. 26° E., 48.6 feet; north-east corner of court-house grounds, N. 40° E., 76 feet.

Distant Mark: North of station 480 feet. It is a sandstone column 36″ × 8″ × 8″; set 36″ in ground on street corner north of court-house. Aluminum bolt in center of stone. Reference marks of same: North-west corner of street, 13.4 feet; north-east corner of street, 68.3 feet; south-west corner of street, 58.5 feet.

Resident Referee: W. C. Dotson, County Clerk.

Magnetic Declination: 1° 04′ W., 10:30 a. m., November 30, 1898. Mean annual change, +03′, approximately.

POCAHONTAS COUNTY.

MARLINTON.

Location: In court-house grounds; 11.9 feet north-east of court-house steps.

Station Mark: Column of sandstone, 42″ × 8″ ×8″; set 36″ in ground, in center of which is a copper plate.

Reference Marks: North-east corner of court-house steps, N. 82° W., 11.9 feet; north-east corner of court-house, N. 80° E., 11 feet; a small elm 3″ in diameter, N. 55° W., 37 feet.

Distant Mark: North of station, 957.6 feet. It is a column of sandstone 30″ × 8″ × 8″; set 30″ in ground on south side of mountain on land owned by Pocahontas Improvement Company. Aluminum bolt in center. Reference marks of same: North-west corner of Iriah Bird's store, S. 3° E., 86 feet; chestnut tree 18″ in diameter, S. 36° W., 40.4 feet; a small chestnut tree 3″ in diameter, S. 84° E., 30 feet.

Resident Referee: S. L. Brown, County Clerk.

Magnetic Declination: 3° 31′, W., 11:20 a. m., August 16, 1898. Mean annual change, +03′, approximately.

PRESTON COUNTY.

KINGWOOD.

Location: South of livery stable on Mr. McRue's land, 3 feet north of south fence.

Station Mark: A column of granite, 44″ × 8″ × 8″; set 39″ in ground, in center of which is a copper plate.

Reference Marks: Apple tree 8″ in diameter, N. 55° W., 46.5 feet; apple tree 8″ in diameter, N. 47° E., 45 feet; church spire bears N. 34° W.; another church spire bears N. 8° E.

Distant Mark: North of station 467.5 feet. It is a granite stone column 8″ × 8″ × 36″; set 36″ in ground in hotel yard, near south-west corner of bowling alley. Aluminum bolt in center of stone. Reference marks of same: South-west corner of bowling alley, north, 4.4 feet; north-west corner of out-house, S. 30° E., 16 feet; north-east corner of bay window of hotel, N. 30° W., 138 feet.

Resident Referee: George A. Walls, County Clerk.

Magnetic Declination: 3° 39′ W., June 26, 1898. Mean annual change, +03′, approximately.

PUTNAM COUNTY.

WINFIELD.

Location: In the court-house grounds opposite the jail.

Station Mark: Column of sandstone 42″ × 8″ × 8″; set 36″ in ground, in the center of which is a copper plate.

Reference Marks: South-west corner of jail, 80 feet; north-west corner of jail, 57.3 feet; north-west corner of McLean's office, 21.8 feet; south-east corner of jail yard, 15.1 feet.

Distant Mark: North of station 308 feet. It is a sandstone column 36″ × 8″ × 8″; set 36″ in ground on the north side of Main street, near the back of Hanly & Craighill's store. Aluminum bolt in center of stone. Reference marks of same: South-east corner of Hanly & Craighill's store, 55.6 feet; north-west corner of Hanly & Craighill's store, 4.6 feet; it is set on the inside of the pavement.

Resident Referee: R. A. Salmons, County Clerk.

Magnetic Declinations: 1° 30′ W., 10:40 a. m., November 18, 1898. Mean annual change, +03′, approximately.

RALEIGH COUNTY.

BECKLEY.

Location: On the north side of walk and south side of Main street; west side of town opposite residence of Mr. Anderson.

Station Mark: Column of sandstone, 42″ × 8″ × 8″; set 36″ in ground, in center of which is a copper plate.

Reference Marks: Small white house, N. 45° E., 98.6 feet; small white house, N. 63° W., 212.5 feet; Anderson's house, S. 32° E., 72.8 feet.

Distant Mark: North of station 1,249.1 feet. It is a sandstone column 36″ × 8″ × 8″; set 36″ in ground on hillside across small ravine. Aluminum bolt in center of stone. Reference marks of same: Black gum tree 8″ in diameter, S. 12° W., 140.8 feet; oak tree 12″ in diameter, N. 53° W., 90.3 feet; pine tree 10″ in diameter, N, 20° E., 27.6 feet.

Resident Referee: J. F. Davis, County Clerk.

Magnetic Declination: 1° 42′ W., 11:00 a. m., October 11, 1898. Mean annual change, +03′, approximately.

RANDOLPH COUNTY.

BEVERLY.

Location: In the south end of town in the yard of Dr. H. Yokum, on the west side of Main street.

Station Mark: Heavy sandstone column, in center of which is a copper bolt.

Distant Mark: North of station 350 feet, and is near the fence on the east side of Main street.

Magnetic Declination: 2° 45′ W., July 29, 1898, Mean annual change, +03′, approximately.

RITCHIE COUNTY.

HARRISVILLE.

Location: On the farm of John Halderman, about three-fourths of a mile south from the court-house. The station is on a ridge just above a farm house and about 800 feet from it; near the lands of Dr. W. E. Talbot and Mr. E. C. Fox.

Station Mark: A heavy sandstone column which projects above the ground, in the center of which is a copper bolt.

Distant Mark: North of station about one mile. Sandstone column similar to the station mark, in the center of which is a copper bolt.

Resident Referee: John W. Cain, Surveyor.

Magnetic Declination: 1° 29′ W., June 22, 1898. Mean annual change, +03′, approximately.

ROANE COUNTY.

SPENCER.

Location: In grounds of State Hospital for the Insane; 45.5 feet east of main entrance to main building.

Station Mark: Column of blue sandstone, 42″ × 8″ × 8″; set 36″ in ground, in the center of which is a copper plate.

Reference Marks: North-east corner of main door, S. 70° W., 45.5 feet; north-east corner of corridor, S. 40° W., 21 feet; north-west corner of east wing, S. 50° E., 37 feet; chimney of power house bears N. 28° W.

Distant Mark: North of station 302 feet. It is a column of blue sandstone, 30″ × 8″ × 8″; set 36″ in ground 131 feet north-east of power house, Aluminum bolt in center. Reference marks of same: north-east corner of Hospital, S. 85° E., 321 feet; south-west corner of power house S. 70° W., 131 feet; south-east corner of power house, N. 75° W., 81 feet.

Resident Referee: M. F. Lewellen, County Clerk.

Magnetic Declination: 1° 43′ W., 10:30 a. m., July 28, 1898. Mean annual change, +03′, approximately.

SUMMERS COUNTY.

HINTON.

Location: In south-east corner of public square.

Station Mark: Column of Ohio sandstone, 42″ × 8″ × 7″; set 36″ in ground, in the center of which is a copper plate.

Reference Marks: Maple tree 6″ in diameter, N. 27° E., 57.7 feet; maple tree 4″ in diameter, S. 64° W., 66.3 feet; north-west corner of Second avenue and James street, N. 83° E., 62 feet.

Distant Mark: North of station 307.3 feet. It is a column of Ohio limestone, 36″ × 8″ × 7″; set 36″ in ground opposite front door of Graham's store, on south side of north sidewalk, 10 feet east of Second avenue. Aluminum bolt in center of stone. Reference marks of same: South-east corner of Graham's store, N. 45° W., 10.4 feet: maple tree 5″ in diameter, East 18 feet.

Resident Referee: J. M. Lavender, City Engineer.

Magnetic Declination: 1° 22′ W., 9:40 a. m., October 20, 1898. Mean annual change, +03′, approximately.

TAYLOR COUNTY.

GRAFTON.

Location: 13 feet east of the north-east corner of St. Johns and Emory streets, near middle of where sidewalk will be.

Station Mark: A column of marble 44″ × 8″ × 8″; set 38″ in ground, in the center of which is a copper plate.

Reference Marks: Maple tree 6″ in diameter, N. 10° W., 22 feet; middle of water tower, S. 41° W., 394 feet.

Distant Mark: North of station 1,061 feet. It is a marble column 30″ × 8″ × 8″; set 30″ in ground on north side of barn-yard, 3 feet south of line of fence. Aluminum bolt in center of stone. Reference marks of same: Sycamore tree 8″ in diameter, N. 58° W., 24.3 feet; walnut tree 16″ in diameter, S., 46° E., 169 feet.

Resident Referee: F. J. Burdette, County Clerk.

Magnetic Declination: 3° 38′ West, June 23, 1898. Mean annual change +03′, approximately.

TUCKER COUNTY.

PARSONS.

Location: In a large vacant lot owned by the W. Va. C. & P. R. R. Co., east of and opposite to the depot.

Station Mark: Column of sandstone 44″ × 8″ × 8″; set 38″ in ground, in center of which is a copper plate.

Reference Marks: Railroad station, N. 35° W., 520 feet; a cherry tree 6″ in diameter, S. 10° E., 49 feet; maple tree 8″ in diameter, S. 5° W., 10 feet.

Distant Mark: North of station, 651 feet. It is a sandstone column similar to station mark; set 36″ in ground on Railroad Company's lot; 5 feet south of fence line which parallels railroad. Aluminum bolt in center. Reference marks of same: Railroad station S. 15° W., 330 feet; fence line 5 feet north.

Resident Referee: William M. Clayton, County Clerk.

Magnetic Declination: 3° 22′ W., 11:00 a. m., July 7, 1898. Mean annual change +03′, approximately.

TYLER COUNTY.

MIDDLEBOURNE.

Location: In Fair Grounds, south-east of Grand Stand, and near south fence of grounds.

Station Mark: A column of sandstone 42″ × 10″ × 8″, set 36″ in ground, in center of which is a copper plate.

Reference Marks: Maple tree, 4″ in diameter, N. 84° E.. 46 feet; south-west corner of Floral Building, N. 32° E., 218.3 feet; south-east corner of Grand Stand, N. 22° W., 128 feet.

Distant Mark: North of station 322 feet. It is a sandstone column 36″ × 8″ × 8″; set 36″ in ground, near the north fence of fair grounds and north-east of Grand Stand. Aluminum bolt in center of stone, Reference marks of same: north-west corner of Floral Building S. 30° E., 107 feet; north-east corner of Grand Stand, S. 18° W., 133.5 feet.

Resident Referee: B. Hickman, County Clerk.

Magnetic Declination: 1° 36′ W., 10:45 a. m., December 3, 1898. Mean annual change +03′, approximately.

UPSHUR COUNTY,

BUCKHANNON.

Location : On the grounds of the West Virginia Conference Seminary, in main lot in front of the present building.

Station Mark : A blue sandstone post with copper station mark in center.

Distant Mark : South of station 450 feet. It is a sandstone column in front of and between the two brick buildings and near a brick walk leading from the south-west corner of lot to the main building.

Resident Referee : W. G. L. Totten and C. L. Mullins, Surveyors, assisted in setting the mark.

Magnetic Declination : 3° 0′ W., July 2, 1898. Mean annual change, +03′, approximately.

WAYNE COUNTY.

WAYNE.

Location: On a hill east of the town of Wayne, on property belonging to Prof. J. B. McClure, and in the lot east of and above his school.

Station Mark: Sandstone column about 1 foot square, and buried so that 8″ project above surface of ground, in center of which is a copper bolt.

Distant Mark: South of station nearly a mile on land owned by Mr. Burwell Ferguson; marked in similar manner to that at the north station.

Resident Referees: Messrs. Joe Plyman and W. H. Atkins, Surveyors.

Magnetic Declination: 0° 45′ W., May 26, 1898. Mean annual change, +03′, approximately.

WAYNE COUNTY.

Second Station—Dunlow.

Location: In pasture lot next to the house of Mr. Thomas Linsby, Superintendent of the Guyandot Coal Land Association. It is 300 feet from the railroad; about 150 feet from bank of Twelve Pole Creek.

Station Mark: Sandstone buried flush with the surface of the ground with copper bolt in center.

Distant Mark: Sandstone buried south of station, flush with the surface of the ground, on hillside on farther side of railroad. Copper bolt in center of stone. Marked in similar manner as station.

Magnetic Declination: 1° 11′ W., May 23, 1898. Mean annual change, +03′, approximately.

WEBSTER COUNTY.

ADDISON.

Location: In grounds of Webster Springs Hotel, 6 feet north of south fence.

Station Mark: A column of sandstone 42″ × 8″ × 8″; set 36″ in ground, in center of which is a copper plate.

Reference Marks: South-east corner of Tenpin alley, S. 16° W., 258 feet; south-west corner of hotel, N. 23° W., 247 feet; south-east corner of hotel, N. 10° W., 270 feet; south-west corner of bath-house, N. 10° E., 369.6 feet.

Distant Mark: North of station, 339.6 feet. It is a sandstone column 30″ × 8″ × 8″; set 30″ in ground. Aluminum bolt in center of stone. Reference marks of same: South-east corner of hotel, S. 22° W., 68 feet; north-east corner of hotel, N. 55° W., 110 feet; north-east corner of bath-house, N. 50° E., 115 feet.

Resident Referee: T. A. Gregory, County Clerk.

Magnetic Declination: 3° 16′ W., 9:40 a. m., August 21, 1898. Mean annual change, +03′, approximately.

WETZEL COUNTY.

New Martinsville.

Location: Inside the race course of the Fair Grounds.

Station Mark: A column of sandstone 42″ × 10″ × 10″; set 36″ in ground, in the center of which is a copper plate.

Reference Marks: Locust tree, 18″ in diameter, N. 85° W., 319.5 feet; south-east corner of Judge's stand, N. 45° W., 288.9 feet; north-east corner of Floral Hall, 12° W., 137.6.

Distant Mark: North of station, 971 feet. It is a sandstone column 36″ × 8″ × 8″; set 36″ in ground, inside of the race course of fair grounds, near the north end. Aluminum bolt in center of stone. Reference marks of same: North-west corner of fair grounds, N. 38° W., 241.3 feet; and a "Granny Mack" apple tree 24″ in diameter, N. 55° E., 149 feet.

Resident Referee: H. R. Thompson, County Clerk.

Magnetic Declination: 0° 59′ W., 10:00 a. m., Dec. 8, 1898. Mean annual change, +03′, approximately.

WIRT COUNTY.

ELIZABETH.

Location: On the south side of Washington street, near the south-east corner of court-house grounds.

Station Mark: A column of sandstone 42″ × 8″ × 8″; set 36″ in ground, in the center of which is a copper plate.

Reference Marks: South-west corner of L. H. Wells' house, 53.6 feet; north-west corner of L. H. Wells' house, 71.5 feet; north-east corner of W. B. Vernon's store, 59.3 feet; north-west corner of W. B. Vernon's store, 18.1 feet.

Distant Mark: North of station, 321.1 feet. It is a sandstone column 36″ × 8″ × 8″; set 36″ in ground in court-house yard, along Main street. Aluminum bolt in center of stone. Reference marks of same; North-west corner of court-house, S. 70° E., 90.2 feet; north-east corner of court-house, east, 65.4 feet.

Resident Referee: S. W. Cain, County Clerk.

Magnetic Declination: 2° 28′ W., 10:00 a. m., November 28, 1898. Mean annual change, +03′, approximately.

WOOD COUNTY.

PARKERSBURG.

Location: In City Park.

Station Mark: A Cleveland sandstone column, 11″.5 × 11″.5 on top; set over three feet in ground, projecting 5″ above the surface of the ground. Copper bolt in center of stone.

Distant Mark: South of station mark, 697 feet, near the house of the park keeper. Copper bolt in center of stone, and stone similar to that at North station.

Magnetic Declination: 1° 14′ W., June 18, 1898. Mean annual change, +03′, approximately.

WYOMING COUNTY.

OCEANA.

Location: On hillside south of town, on land owned by Mrs. M. A. Conley.

Station Mark: A column of sandstone 42″ × 8″ × 8″; set 36″ in ground, in the center of which is a copper plate.

Reference Marks: Apple tree, 8″ in diameter, N. 61° W., 31.9 feet; chestnut tree 24″ in diameter, N. 85° E., 164 feet; chestnut tree, 30″ in diameter, S. 33° E., 127.2 feet; chestnut tree, 28″ in diameter, S. 11° W., 136.2 feet.

Distant Mark: North of station 1,430.4 feet. It is a sandstone column 36″ × 8″ × 8″; set 36″ in ground on hillside north of town, on land owned by G. & B. H. Chambers, Executors of L. B. Chambers. Aluminum bolt in center of stone. Reference marks of same: Oak tree, 18″ in diameter, N. 21° W., 127 feet; chestnut tree, 22″ in diameter, N. 73° E., 147.8 feet; flag pole on Kelley Hotel bears S. 7° W.

Resident Referee: T. W. Cook, County Clerk.

Magnetic Declination: 1° 37′ W., 10:30 a. m., October 5, 1898. Mean annual change, +03′, approximately.

Part IV.

PETROLEUM AND NATURAL GAS.

Historical Sketch.

The early history of *petroleum* and *natural gas* is much the same in every country where they occur. In China the utilization of natural gas antedates authentic history. In Persia, Arabia, India, Albania, and other countries, rock oil, or petroleum, and its residuum, pitch, have been in use for many centuries, as attested by such writers as Aristotle, Strabo, Plutarch, Pliny, Marco Polo and others, while the ruins of the ancient temple of the Parsees or Fire-worshipers at Baku, where natural gas and petroleum have been issuing from the earth, and bubbling up through the waters of the Caspian Sea for untold ages, simply accentuate the story of every other country.

The ancient gravel pits near Titusville, Pennsylvania, show that the American Indian had some knowledge of the value of petroleum, before the white man had

invaded the region, and it is quite probable that the "burning springs," and outflows of petroleum, on the Little and Big Kanawhas, Big Sandy and other streams of West Virginia, had already attracted the attention of the aborigines, and that they were making use of them in their own primitive way, long before the first white settlers crossed the Alleghanies.

Gen. Washington's Discovery of a Natural Gas Spring.

One of the earliest records of these natural gas vents or "burning springs" is of that on the Great Kanawha, nine miles above Charleston, near the crest of the Browntown anticlinal. General Washington visited this "burning spring" in 1775, and pre-empted it along with other lands given to him for military services by the State of Virginia. In his will this natural gas wonder, together with a square acre of ground around it, was deeded to the public forever, and the following reference to its acquisition is recorded: "The tract of which the 123 acres is a moiety was taken up by Gen. Andrew Lewis and myself for, and on account of, a *bituminous spring*, which it contains, of so inflammable a nature as to burst forth as freely as spirits and is nearly as difficult to extinguish."

Drilling Machinery and Methods Invented in the Great Kanawha Valley.

It is not generally known that all of the essential elements of the petroleum industry of the United States really originated in what is now West Virginia, but such is the truth of history. It was in the Great Kanawha Valley at the Salt, or Buffalo Lick, near Charleston, where, under the intelligent and successful at-

tempts of the Ruffner Bros. (David and Joseph) to bore down through the rocks and ascertain the source of the famous salt water spring, that modern *drilling tools*, *jars*, *casing*, and practically all of the oil well machinery in use at the present day were invented. These boring operations were begun by the Ruffner Brothers (David and Joseph) in 1806, and their efforts were crowned with success on the 15th day of January, 1808. The story of these early drilling operations and inventions has been given in a detailed and interesting sketch by Dr. J. P. Hale, President of the West Virginia Historical Society, Charleston, W. Va., in the "Resources of West Virginia," 1876, by M. F. Maury and Wm. M. Fontaine, Chapter XII, pages 274–305, and as that volume is now out of print, the main portion of the chapter is here reproduced, beginning with page 273, as follows:

The Early Drilling Operations of David and Joseph Ruffner in the Great Kanawha Valley.

"The Kanawha Salt Works are situated in Kanawha county, on the Kanawha river, commencing about three miles above Charleston and extending up the river for several miles, on both sides..

These "Licks," as they are called, have not only been known and extensively worked, from the first settlement of the valley by the whites, but have been known and used from time immemorial by the Indian tribes, and frequented by swarms of buffalo, elk, deer, and other wild animals, before the advent of the white man.

In 1753, when all this region was an unbroken wilderness, which had never been penetrated by the most adventurous white man, a party of Shawnees who dwelt upon the Scioto, in what is now Ohio, made a raid upon the frontier settlements of Virginia, in what is now Montgomery county. Having taken the settlers unawares, and after killing, burning, and capturing prisoners, as was their custom, they retreated, with their captives, down New River, Kanawha, and Ohio, to their homes. One of these captives, Mrs. Mary Ingles, who afterwards made her escape, and was returned to her friends, related that the party stopped several days at a salt spring on the Kanawha river, rested from their weary march, killed plenty of game and feasted themselves on the fat of the land; in the meantime, boiling salt water and making a supply of salt, which was carefully packed and taken

home with them to their western homes. This is not only the first account we have of salt making on the Kanawha, but anywhere else west of the Alleghanies. In fact, if there is any earlier record of salt-making from brine springs, anywhere in the United States, I am not aware of it.

The earliest settlement made by the whites in the Kanawha valley, was made by Walter Kelley and family, at the mouth of the creek, which bears his name, in the spring of 1774, several months before the battle of Point Pleasant, where the combined Indian tribes, under the celebrated Sachem, Cornstalk, were defeated and driven back by the Virginians, under Gen. Lewis.

Kelley and his family paid the forfeit of their lives to their temerity ; they were all killed by the Indians : but after the battle of the Point, when there was greater security for life, the Valley was rapidly settled, mostly by Virginians, and in great part by the hardy soldiers who had followed Lewis to Point Pleasant.

The early pioneer settlers, in a wilderness, without communication with other settlements, except by foot or bridle paths, depended upon the Kanawha Licks for their scanty supply of salt. In those days of simple economy and provident thrift, when everything useful was made the most of, the women's wash-kettles were put under requisition for a four-fold duty ; they boiled the daily hog and hominy, and other wholesome, frugal fare ; once a week they boiled the clothes, on wash day ; semi-occasionally they boiled the salt water for a little of the precious salt, and every spring they went to the sugar camp, to boil the annual supply of maple sugar and molasses.

It is related that at one time, when there was an apprehended attack from the Indians, the few early settlers were posted at the mouth of Coal river, for protection. Being out of salt and suffering for the want of it, they sent some of their hardy and daring young men in canoes up to the salt spring, where they dipped the canoes full of salt water ; and, getting safely back, the water was boiled, and the precious salt made under cover of the fort.

Among the earliest land locations made in the valley, was one of 502 acres, made in 1785, by John Dickinson, from the Valley of Virginia, to include the mouth of Campbell's creek, the bottom above and the salt spring. Dickinson did not improve or work the property himself, but meeting with Joseph Ruffner, an enterprising farmer from the Shenandoah Valley, Virginia, in 1794, and describing this salt spring to him, Ruffner became so impressed with its value, that he then and there purchased the 502 acres upon Dickinson's own report, without himself seeing it, agreeing to pay for it 500 pounds sterling without condition, and other sums conditioned upon the quantity of salt to be made which might increase the price to 10,000 pounds sterling. Having gone thus far, he sold out his Shenandoah estates, and in 1795 removed himself and family to Kanawha to look after his salt property. Upon arriving here, however, his penchant for rich farming lands overcame him, and he purchased from George and William Clendenen the large river bottom of 900 acres extending from the mouth of Elk river up the Kanawha, and, upon 40 acres of which the village of Charles-

ton had been laid out and started the previous year. This last purchase, and the subsequent attention to clearing and improving the farm diverted Ruffner's attention for a time, from the salt project; the delay was fatal so far as he was concerned; he did not live to execute his pet scheme or realize his cherished hopes. Dying in 1803, he willed the property to his sons, David and Joseph, enjoining it upon them to carry out, as speedily as practicable, his plans of building up extensive salt manufactories to supply not only the increasing local demand, but a larger and still more rapidly growing demand which was now coming from the many thrifty settlements throughout the Ohio Valley. During the elder Ruffner's life, however, he had leased to one Elisha Brooks the use of salt water and the right to manufacture salt, and in 1797, this Elisha Brooks erected the first salt furnace in Kanawha or in the western country. It consisted of two dozen small kettles, set in a double row, with a flue beneath, a chimney at one end, and a fire bed at the other.

To obtain a supply of salt water, he sank two or three "gums," some 8 or 10 feet each in length, into the mire or quick-sand of the salt lick, and dipped the brine with a bucket and swape, as it oozed and seeped through the sands below.

In this crude, rough and ready way, Brooks managed to make about 150 pounds of salt per day, which he sold at the kettles, at 8 to 10 cents per pound. No means were used to settle or purify the brines or salt, as the salt water came from the gum, so it was boiled down to salt in the kettles, with whatever impurities or coloring matter it contained. As it issues from the earth it holds some carbonate of iron in solution; when it is boiled, this iron becomes oxidized, and gives a reddish tinge to the brine and salt.

This Kanawha salt soon acquired a reputation for its strong, pungent taste, and its superior qualities for curing meat, butter, etc. A great many who used it and recognized these qualities in connection with its striking reddish color came to associate the two in their minds in the relation of cause and effect, and orders used to come from far and near for some of "that strong, red salt from the Kanawha Licks"

Almost the only mode of transporting salt beyond the neighborhood in those early days was by pack-horses, on the primitive, back-woods pack-saddle. So much of this was done, and so familiar did the public mind become with the term, as used in that sense, that even to this day, among a large class of people, the verb "to pack" is always used instead of other synonymous or similar terms, such as carry, transport, fetch, bring, take, etc., and the "tote" of Old Virginia.

It was not until 1806, that the brothers, David and Joseph Ruffner, set to work to ascertain the source of the salt water, to procure, if possible, a larger supply and of better quality, and to prepare to manufacture salt on a scale commensurate with the growing wants of the country.

The Salt Lick, or the "Great Buffalo Lick," as it was called, was just at the river's edge, 12 or 14 rods in extent, on the north side, a few hundred yards above the mouth of Campbell's creek, and just in front of what is now

known as the "Thoroughfare Gap," through which, from the north, as well as up and down the river, the buffalo, elk and other ruminating animals made their way in vast numbers to the lick. I may mention *en passant* that so great was the fame of this lick, and the herds of game that frequented it, that the great hunter, explorer, and conqueror of the "bloody ground" of Kentucky, Daniel Boone, was tempted up here, made a log cabin settlement, and lived on the opposite side of the river, on what is now known as the Donally farm or splint coal bottom. I have had from old Mr. Paddy Huddlestone, who died a few years ago, at nearly one hundred years of age, many interesting anecdotes of their joint adventures in hunting and trapping. Boone still lived here, in 1789-90, when Kanawha county was formed, and in 1791 served as one of the delegates for the county, in the Legislature at Richmond.

But to return to the Lick and the operations of the Ruffner Brothers. In order to reach, if possible, the bottom of the mire and oozy quick-sand through which the salt water flowed, they provided a straight, well-formed, hollow sycamore tree, with four feet internal diameter, sawed off square at each end. This is technically called a "gum." This gum was set upright on the spot selected for sinking, the large end down, and held in its perpendicular position by props or braces, on the four sides. A platform upon which two men could stand, was fixed about the top; then a swape erected, having its fulcrum in a forked post set in the ground close by. A large bucket, made from half of a whiskey barrel, was attached to the end of the swape, by a rope, and a rope attached to the end of the pole to pull down on, to raise the bucket. With one man inside the gum armed with pick, shovel and crowbar, two men on the platform on top to empty and return the bucket, and three or four to work the swape, the crew and outfit were complete.

After many unexpected difficulties and delays, the gum, at last, reached what seemed to be rock bottom, at 13 feet; upon cutting it with picks and crowbars, however, it proved to be but a shale or crust, about six inches thick, of conglomerated sand, gravel and iron. Upon breaking through this crust the water flowed up into the gum more freely than ever, but less salt.

Discouraged at this result, the Ruffner brothers determined to abandon this gum and sink a well out in the bottom, about 100 yards from the river. This was done, encountering as before, many difficulties and delays; when they had gotten through 45 feet of alluvial deposit they came to the same bed of sand and gravel upon which they had started at the river.

To penetrate this, they made a 3½ inch tube of a 20-foot oak log, by boring through it with a long shanked augur. This tube, sharpened and shod with iron at the bottom, was driven down, pile driver-fashion, through the sand to the solid rock. Through this tube they then let down a glass vial with a string to catch the salt water for testing.

They were again doomed to disappointment; the water, though slightly brackish, was less salt than that at the river. They now decided to return to the gum at the river, and, if possible, to put it down to bed rock. This they finally succeeded in doing, finding the rock at 16 to 17 feet from the surface.

As the bottom of the gum was square and the surface of the rock uneven, the rush of outside water into the gum was very troublesome. By dint of cutting and trimming from one side and the other, however, they were, at last, gotten nearly to a joint, after which they resorted to thin wedges, which were driven here and there as they would "do the most good."

By this means the gum was gotten sufficiently tight to be so bailed out as to determine whether the salt water came up through the rock. This turned out to be the case. The quantity welling up through the rock was extremely small, but the strength was greater than any yet gotten, and this was encouraging. They were anxious to follow it down, but how? They could not blast a hole down there, under water; but this idea occurred to them; they knew that rock blasters drilled their powder holes two or three feet deep, and they concluded they could, with a longer and larger drill, bore a correspondingly deeper and larger hole.

They fixed a long iron drill, with a 2½ inch chisel bit of steel, and attached the upper end to a spring pole, with a rope. In this way the boring went on slowly and tediously till on the 1st of November, 1807, at 17 feet in the rock, a cavity or fissure was struck, which gave an increased flow of stronger brine. This gave new encouragement to bore still further; and so, by welding increased length of shaft to the drill, from time to time, the hole was carried down to 28 feet, where a still larger and stronger supply of salt water was gotten.

Having now sufficient salt water to justify it, they decided and commenced, to build a salt furnace; but while building, continued the boring, and on the 15th of January, 1808, at 40 feet in the rock, and 58 feet from the top of the gum, were rewarded by an ample flow of strong brine for their furnace, and ceased boring.

Now was presented another difficulty: how to get the stronger brine from the bottom of the well, undiluted by the weaker brines and fresh water from above; there was no precedent here; they had to invent, contrive and construct anew. A metal tube would naturally suggest itself to them; but there were neither metal tubes, nor sheet metal, nor metal workers—save a home-made blacksmith—in all this region, and to bore a wooden tube 40 feet long, and small enough in external diameter to go in the 2½ inch hole, was impracticable; what they did do, was to whittle out of two long strips of wood, two long half tubes of the proper size, and, fitting the edges carefully together, wrap the whole from end to end with small twine; this, with a bag of wrapping near the lower end, to fit, as nearly as practicable, water tight, in the 2½ inch hole, was cautiously pressed down to its place, and found to answer the purpose perfectly; the brine flowed up freely through the tube

into the gum, which was now provided with a water tight floor or bottom, to hold it ; and from which it was raised by the simple swape and bucket.

Thus was bored and tubed, rigged and worked, the first rock-bored salt well west of the Alleghanies, if not in the United States. The wonder is not that it required eighteen months or more to prepare, bore and complete this well for use, but, rather, that it was accomplished at all under the circumstances. In these times, when such a work can be accomplished in as many days as it then required months, it is difficult to appreciate the difficulties, doubts, delays and general troubles that beset them then. Without preliminary study, previous experience or training, without precedents in what they undertook, in a newly settled country, without steam power, machine shops, skilled mechanics, suitable tools or materials, failure, rather than success, might reasonably have been predicted.

The new furnace which for sometime had been under construction, was now complete. It was simply a reproduction of the Elisha Brooks kettle furnace on a larger scale. There were more kettles, of larger size, and better arranged.

On the 8th of February, 1808, the Ruffner Bros., made their first lifting of salt from this furnace, and simultaneously reduced the price to the, then, unprecedentedly low figure of four cents per pound.

From this time forward, salt making, as one of the leading industries of Kanawha, was an established fact, and Kanawha salt one of the leading commercial articles of the west ; and wherever it has gone, from the Alleghanies to the Rocky Mountains, from the Lakes to the Gulf, its superior qualities have been recognized and appreciated.

The neighboring property owners who had watched the progress and result of the Ruffner well with such deep interest, now instituted borings on their own lands, above and below, and on both sides of the river. Among these early enterprising experimenters were William Whitaker, Tobias Ruffner, Andrew Donally, and others. All were more or less successful in getting a supply of brine, at depths varying from 50 to 100 feet, and by 1817 there were some 30 furnaces and 15 or 20 wells in operation, making in the aggregate 600,000 or 700,000 bushels of salt.

In this year an important revolution in the manufacture of salt was effected by the discovery of coal. Although, in one of the finest coal fields in the world, coal had not, hitherto, been found here in workable seams, nor been used at all, except for blacksmith purposes. Wood had been the only fuel used in salt making, and for other purposes, and all the bottoms and convenient hill slopes for several miles up and down the river had been stripped of their timber to supply this demand.

David Ruffner, true to the spirit of enterprise, and pluck, which bored the first well, was the first here to use coal as a fuel. This would appear to be a very simple matter now ; but was not so then. It was only after many months of discouraging efforts, and failing experiments, that he finally succeeded in getting it to work to his satisfaction. Its value established, how-

ever, its use was, at once, adopted by the other furnaces, and wood ceased to be used as a fuel for salt making in Kanawha.

Other important improvements were gradually going on in the manner of boring, tubing and pumping wells, &c. The first progress made in tubing, after Ruffner's compound wood-and-wrapping-twine tube, was made by a tinner who had located in Charleston to make tin cups and coffee pots for the multitude. He made tin tubes in convenient lengths and soldered them together as they were put down the well. The refinement of screw joints had not yet come, but followed shortly after, in connection with copper pipes, which soon took the place of tin, and these are recently giving place to iron.

In the manner of bagging the wells, that is, in forming a water-tight joint around the tube to shut off the weaker waters above from the stronger below, a simple arrangement, called a "seed-bag," was fallen upon, which proved very effective, which has survived to this day, and has been adopted wherever deep boring is done, as one of the standard appliances for the purpose for which it is used. This seed-bag is made of buckskin, or soft calfskin, sewed up like the sleeve of a coat or leg of a stocking; made 12 to 15 inches long, about the size of the well hole and open at both ends; this is slipped over the tube and one end securely wrapped over knots placed on the tube to prevent slipping. Some six or eight inches of the bag is then filled with flaxseed, either alone or mixed with powdered gum tragacanth; the other end of the bag is then wrapped like the first, and the tube is ready for the well. When to their place—and they are put down any depth, to hundreds of feet— the seed and gum soon swell from the water they absorb, till a close fit and water-tight joint are made.

The hydraulic contrivance for raising salt water from the gums, consisting of a bucket, a swape and a man, was simple, slow and sure; but the spirit of progress was abroad and it soon gave place to a more complicated arrangement, consisting of a pump, lever, crank, shaft, and blind horse or mule, that revolved in its orbit around the shaft. This was considered a wonderful achievement in mechanical contrivance, especially by the men who had worked the swapes.

For several years this "horse-mill," as it was called, was the only mode of pumping salt water on Kanawha, but in the fulness of time it also went to the rear in 1828 and the steam engine came to the front, not only for pumping, but also for boring wells and various other uses.

In 1831 William Morris, or "Billy" Morris, as he was familiarly called, a very ingenious and successful practical well borer, invented a simple tool, which has done more to render deep boring practicable, simple and cheap, than anything else since the introduction of steam.

This tool has always been called here "Slips," but in the oil regions they have given it the name of "Jars." It is a long double link with jaws that fit closely, but slide loosely up and down. They are made of the best of steel, are about 30 inches long, and fitted, top and bottom, with pin and socket joint, respectively. For use they are interposed between the heavy

iron sinker, with its cutting chisel bit below, and the line of augur poles above. Its object is to let the heavy sinker and bit have a clear, quick, cutting fall, unobstructed and unencumbered by the slower motion of the long line of augur poles above. In the case of fast augur or other tools in the well, they are also used to give heavy jars upward or downward, or both, to loosen them. From this use the oil well people have given them the name of "Jars."

Billy Morris never patented his invention, and never asked for nor made a dollar out of it, but as a public benefactor he deserves to rank with the inventors of the sewing machine, planing machine, printing cylinders, cotton gin, &c.

This tool has been adopted into general use wherever deep boring is done, but, outside of Kanawha, few have heard of Billy Morris, or know where the slips or jars came from.

The invention of this tool, the adoption of the heavy sinker and some other minor improvements in well boring, gave a great impetus to deep boring in Kanawha. Wells were put down 500, 1,000, 1,500 and 1,800 feet, and one, the deepest in Kanawha, by Charles Reynolds, to about 2,000 feet. These borings would doubtless have been carried to a much greater depth, but that the fact soon got to be understood that the salt-bearing strata had been passed, and that no brines were obtained at a greater depth than 800 to 1,000 feet. The limit of the salt-bearing rocks is readily told by the character of the borings. Within this limit are sandstones, shale, coal, &c., of the Coal Measures lying nearly horizontal, though dipping slightly to the northwest; below is the Carboniferous Limestone which underlies the Coal Measures, and crops out 100 miles to the eastward. This limestone, when penetrated, is known to the well-borers as the "long-running rock," from the fact that a boring-bit will run a long time in it without being dulled.

No regular suites of samples of borings from the Kanawha wells have ever been kept. This is not important, however, as the strata are well known, and can be examined along the New River canon as they crop out to the eastward.

The Kanawha borings have educated and sent forth a set of skillful well-borers, all over the country, who have bored for water for irrigation on the western plains, for artesian wells for city, factory, private use, for salt water at various places, for oil all over the country, for geological or mineralogical explorations, &c., &c.

Nearly all the Kanawha salt wells have contained more or less petroleum oil, and some of the deepest wells a considerable flow. Many persons now think, trusting to their recollections, that some of the wells afforded as much as 25 to 50 barrels per day. This was allowed to flow over from the top of the salt cisterns, on to the river, where, from its specific gravity, it spread over a large surface, and by its beautiful irridescent hues, and not very savory odor, could be traced for many miles down the stream. It was from this that the river received the familiar nickname of "Old Greasy,"

by which it was for a long time familiarly known by Kanawha boatmen and others.

At that time this oil not only had no value, but was considered a great nuisance, and every effort was made to tube it out and get rid of it.

In 1775, Gen. Washington visited the Kanawha valley in person, and located some very valuable lands for his military services. About three miles above the Salt Lick, he set apart and deeded to the public, forever, a square acre of land near the river, on which was a great natural wonder, then little understood, called a "burning spring." For many years after, it was visited by every one who came to or passed through Kanawha, as one of the great curiosities of the region. It was simply a hole in the ground, which filled with water when it rained, and up through which issued a jet of gas, giving the water the appearance of boiling, and when lighted burned with a bright flame till blown out by high wind.

In 1841, William Tompkins, in boring a salt well a short distance above the burning spring, struck a large flow of gas, which he turned to account by "boiling his furnace" and making salt with it, effecting a great saving in fuel and economy in the cost of salt.

In 1843, Messrs. Dickinson & Shrewsberry, boring a few rods below, tapped at about 1,000 feet in depth, nature's great gas reservoir of this region. So great was the pressure of this gas, and the force with which it was vented through this bore-hole, that the augur, consisting of a heavy iron sinker, weighing some 500 pounds, and several hundred feet more of augur poles, weighing in all, perhaps 1,000 pounds, was shot up out of the well like an arrow out of a cross-bow. With it came a column of salt water, which stood probably 150 feet high. The roaring of this gas and water, as they issued, could be heard under favorable conditions for several miles.

It would have been difficult to estimate with any approach to accuracy, the quantity of gas vented by this well, and no attempt was made to measure it. I heard it roughly estimated as being enough to light London and Paris, with, perhaps, enough left to supply a few such villages as New York and Philadelphia. But as this is a *salt* well, as well as *gas* well, I suggest that the gas estimates be taken, *cum grano salis*.

While this well was blowing it was the custom of the stage drivers, as they passed down by it, to stop and let their passengers take a look at the novel and wonderful display. On one occasion a professor from Harvard College was one of the stage passengers, and being a man of investigating and experimenting turn of mind, he went as near the well as he could get for the gas and spray of the falling water, and lighted a match to see if the gas would burn. Instantly the whole atmosphere was ablaze, the Professor's hair and eye-brows singed, and his clothes afire. The well-frame and engine-house also took fire, and were much damaged. The Professor, who had jumped into the river to save himself from the fire, crawled out, and back to the stage as best he could, and went on to Charleston, where he took to bed, and sent for a doctor to dress his burns.

Col. Dickinson, one of the owners of the well, hearing of the burning of

his engine-house and well-frame, sent for his man of affairs, Col. Woodyard, and ordered him to follow the unknown stage passenger to town, get warrant, have him arrested and punished, for wilfully and wantonly burning his property,—unless, concluded Col. Dickinson, as Woodyard was about starting, unless you find that the fellow is a natural d——d fool, and didn't know any better. Arriving at Charleston, Woodyard went to the room of the burnt Professor at the hotel, finding him in bed, his face and hands blistered, and in a sorry plight generally. He proceeded to state in very plain terms, the object of his visit, at which the Professor seemed greatly worried and alarmed, not knowing the extent of this additional impending trouble, which his folly had brought upon him. Before he had expressed himself in words, however, Woodyard proceeded to deliver, verbatim, and with great emphasis the codicil to Dickinson's instructions. The Professor, notwithstanding his physical pain and mental alarm, seemed to take in the ludicrousness of the whole case, and with an effort to smile through his blisters, replied that it seemed a pretty hard alternative; but under the circumstances, he felt it his duty to confess under the last clause, and escape. Well, said Woodyard, if this is your decision, my duty is ended, and I bid you good morning.

The salt water and gas from this well were partially collected and conveyed through wooden pipes, to the nearest furnace, where they were used in making salt.

For many years this natural flow of gas lifted the salt water 1,000 feet from the bottom of the well, forced it a mile or more through pipes, to a salt furnace, raised it into a reservoir, boiled it in the furnace, and lighted the premises all around at night. About the only objection to the arrangement was, that it did not lift the salt and pack it in barrels.

The success of this well induced other salt makers to bore deep wells for gas, and several were successful. Messrs. Worth & English, Tompkins, Welch & Co., Wm. D. Shrewsberry, J. H. Fry, and J. S. O. Brooks, got gas wells and used the gas either alone, or in counection with coal, for fuel, in salt making. Gas was also struck in a few other wells, but did not last long, and was not utilized.

The first flow of gas ever struck in Kanawha, was as far back as 1815, in a well bored by Capt. James Wilson, within the present city limits of Charleston, near the residence of C. C. Lewis, Esq.

The Captain had not gotten as good salt water as he expected; but instead of being discouraged, he declared in language emphatic, that he would have better brine or bore the well into ——— lower regions, with higher temperature.

Shortly after this the augur struck a cavity which gave vent to an immense flow of gas and salt water. The gas caught fire from a grate near at hand, and blazed up with great force and brilliancy, much to the consternation of the well-borers and others. Capt. Wilson thought it would be a reckless tempting of providence to go any deeper, and ordered the boring stopped.

This well is now owned by the Charleston Gas Light Company, which at some future time contemplates re-opening it to test the gas for lighting the city.

Of the many wells in the neighborhood that have furnished gas, some have stopped suddenly, and some by a slow and gradual process. Whether these stoppages have been from exhaustion of the gas, or sudden or gradual stoppage of the vent-ways, has not been definitely determined. It is known, however, that in the Dickinson and Shrewsberry well, which blew longer than any other, that the copper pipes in the well, and the wooden pipes leading to the furnace, were lined with a mineral deposit in some places nearly closing them. This deposit has not been analyzed, but may possibly be silicate of lime. A system of torpedoing might break up these incrustations from the walls of the well and rock cavities, and start the gas again."

Natural Gas First Used for Manufacturing Purposes in the Kanawha Valley.

From these facts as given by Dr. Hale, it will be perceived that the claim of priority for West Virginia in all of the essential elements of the petroleum industry of the United States, is fully sustained, for here were invented practically all of those tools and appliances without which the deep drilling of the present day would be impossible. This record also shows that the use of natural gas for manufacturing purposes was first begun within the United States by Mr. Tompkins of the Kanawha Valley, a utilization which now plays such an important part in industrial affairs, and which is destined to continue until the *age of gas* is fully inaugurated, and the general use of coal in its crude or unmanufactured condition is abandoned in all populous communities. The extravagant methods which have characterized the first decade of the recent greatly increased use of natural gas, will have been largely compensated for, should they finally lead to the use of coke instead of coal, and to the saving of the gas for fuel and general heating purposes which is now lost in our wasteful and unscientific coke ovens of the beehive pattern.

Petroleum Discovered in the Early Salt Borings.

In these early salt borings on the Great Kanawha, considerable quantities of petroleum were often found in the sands of the Coal Measures (Freeport and Pottsville series,) and much of it was utilized in oiling machinery and for torch lights, while many barrels of it were transported and sold to other regions.

The methods of boring invented on the Kanawha soon spread to adjoining States, especially to Ohio, where in the Muskingum region, efforts to secure brine for salt manufacture, led to discoveries of petroleum and natural gas, just as they had previously done on the Great Kanawha.

Dr. Hildreth's Account of the Early Petroleum Industry

Very fortunately for science, a learned and accomplished physician, who was also one of the pioneer geologists of Ohio, Dr. S. P. Hildreth, resided at Marietta during the early period in petroleum history, and he has left a carefully written account of these drilling operations and their results from which we get a glimpse of the beginning of the petroleum industry in Ohio, and by inference therefrom, its previous history in what is now West Virginia. This article was published in the American Journal of Science and Arts, Vol. X, New Haven, Connecticut, February, 1826, pages 1-8 inclusive, under the title of "Facts relating to certain parts of the State of Ohio," by S. P. Hildreth, M. D. After speaking of limestone that is thick and abundant, he continues on page 4 as follows:

"Below these beds of limestone you pass through a stratum of clay, sometimes of fossil coal; this is of various depths in different parts of the county;* after which you come to that vast and extensive bed of rock, which

*Washington county.

underlies the country from the Alleghany mountains to the Mississippi river, for aught I have heard. The thickness of this rock has never been ascertained, but, at the depth of from 150 to 400 feet, this rock is strongly impregnated with salt, and if on boring to that depth you are so fortunate as to find water, I believe that water invariably holds in solution a greater or less quantity of the muriate of soda. Two attempts at boring for salt water have been made in this county. The first was made two or three years since, about 40 miles from Marietta, near the Muskingum river; they proceeded to the depth of about 200 feet, and their prospects of obtaining water rather diminishing than increasing, they gave up the work. The other trial is now making, on the waters of Little Muskingum creek, about 12 miles from Marietta. It is two years since they began to bore, working at it only in the summer and autumnal months. They have penetrated the rock to the depth of 300 feet, and have as yet found no salt water; but the cattle are very fond of licking the fine dust of the rock, which comes up on the drills in the form of mud, which is an evidence that it contains salt. There is a continual discharge of *carbonated hydrogen* gas from the well; and also from the bed of the creek on which the well is situated, at various places for the distance of half a mile. This gas is highly inflammable, and where there is a free discharge of it, it will take fire on the surface of the water, on the application of a lighted stick, or the flash of a gun, and continue burning for days, unless put out by a heavy shower or a high wind. It was this discharge of gas that induced the present proprietors to search for salt water. It being invariably found to accompany all the salt water of any consequence, that has been discovered in the western country.*

'It is this discharge of gas that brings the salt water from such vast depths in the bowels of the earth, to the surface. And where water has been discovered, and the supply of gas has failed, the water has immediately sunk in the well, and could not, by any means used, be brought again to the top of the well.

They commonly bore, at the wells on Little Muskingum, to the depth of 400 to 500 feet, unless salt water is found before they reach that distance. They are encouraged then to continue, from their knowledge of the depth at which others obtained very good water, on the west branch of Duck creek, four or five miles above the line of Washington, in Guernsey county. They have sunk two wells which are now more than 400 feet in depth. One of them affords a very strong and pure water, but not in great quantity. The other discharges such vast quantities of petroleum, or as it is vulgarly called, "Seneka oil," and besides is subject to such tremendous explosions of gas, as to force out all the water, and afford nothing but gas for several days, that they make but little or no salt. Nevertheless the petroleum affords considerable profit, and is beginning to be in demand for lamps, in workshops and manufactories. It affords a clear, brisk light when burnt this way, and will be a valuable article for lighting the street lamps in the future cities of Ohio."

"The rock in which these wells are sunk is of various density and compo-

*Evidently referring to the Great Kanawha Valley.—I. C. W.

sition. In some places for one or two feet the workmen can gain only an inch or perhaps half an inch in a day, and then they have their drills to sharpen every few minutes; the rock is so much harder than the hardest steel that it is very difficult to get a drill to stand it at all.

At other places in the rock they penetrate from one to two feet in a day. In this course of drilling they often pass through as many as three or four layers of fossil coal, at various depths in the rock; and it is generally the fact, that immediately after the salt water appears, they pass a stratum of stone coal of considerable thickness, perhaps six or eight inches."

Early Use of Petroleum Shown by Dr. Hildreth.

This interesting account, it must be remembered, was published in 1826, and as may be seen from the same, petroleum was then coming into general use for illuminating purposes in the region. Now, as it is well known that the well borers of Ohio learned their art in the Great Kanawha Valley many years before (1806-1820,) where much petroleum had been found in boring for salt, and utilized in the same manner as on the Muskingum, it can readily be seen that the Great Kanawha Valley region of West Virginia (then a part of Virginia) was the real pioneer in the discovery of petroleum by boring, and that it, as well as natural gas, was first utilized on a commercial scale in the Kanawha Valley, so that the account which Dr. Hildreth has left concerning the discovery and use of petroleum on the Muskingum, might have been written fifteen years earlier for the Great Kanawha, had the geologist lived at Charleston instead of Marietta. As a matter of fact Dr. Hildreth did visit the Great Kanawha, as well as the Little Kanawha region soon after 1826, for in 1836 he published a long paper in the American Journal of Science, Vol. 29, entitled "Observations on the Bituminous Coal Deposits of the Valley of the Ohio," in which on page 121 he describes the petroleum found in the salt wells near Charleston, the oil and gas on the

Big Sandy (page 129,) and the oil pits on Hughes River (page 86.)

In another paper published in Vol. 24 of the same journal, in 1833, "On the Saliferous Rock Formations in the Valley of the Ohio," page, 46, he describes one of the earliest oil wells of the country, drilled in 1814, and located on the land of Mr. McKee, on Duck Creek. This well had been bored for salt water, and at a depth of 475 feet (evidently in the Dunkard or Cow Run Sand) had struck a flowing oil well, which at first produced a large quantity of oil, "flowing 30 to 60 gallons at each eruption, but now (1833) only one barrel weekly."

Little Kanawha, Hughes River, etc.

The Little Kanawha river and its principal tributary, the Hughes, have also played very important parts in the early petroleum history of the country.

A prominent anticlinal axis crosses the Great Kanawha near the "burning spring," and probably the same uplift extending to the north across the Little Kanawha, the Hughes, the Ohio, and up into the Muskingum region, developes a line of "*burning*" and *petroleum* "*springs*" throughout its course, so that the Little Kanawha also had its "*burning springs*," as well as the Great Kanawha. Where this arch crosses Hughes river near the California House, two miles below the junction of the North and South Forks, it brings one of the "shallow sand" oil rocks (Dunkard) above drainage level, and the oil seepage from this and the underlying beds had long ago filled the flood plain sands and clays with oil. Just when this surface deposit of oil was first observed, and collected, we have no authentic account, but probably from the earliest settlement of the region by the whites, and possibly

earlier still by the aborigines. As related above, it was first described by Dr. Hildreth in 1836, who states that 50 to 100 barrels were collected and sold during each season, even at that early day, and hence the industry must have existed for many years before.

Early Oil Operations of Mr. George S. Lemon, on Hughes River.

The flood plain deposits or river sands which held the oil were situated on the right bank of the stream, and the first settlers dug pits into them, washed out the oil, and collected it with cloths and in other primitive ways for the markets at Parkersburg, Marietta, Cincinnati and elsewhere. One of the early operators engaged in the business of collecting and marketing this "mud oil," as it was called, of whom we have an authentic account, was Mr. George S. Lemon, who came from eastern Virginia in 1835 and settled at the forks of Hughes river. The oil deposits two miles below were well known at that time, and Mr. Lemon soon began the business of collecting and selling the oil. In his employ was an intelligent mulatto named Hugill, or Hugle, who had learned the well-borer's art on the Great Kanawha, and being in need of salt, Mr. Lemon concluded to sink a well for brine on the left bank of Hughes River, and 300 yards above the oil pit diggings, at a locality where he had noticed cattle licking the rocks. Aided by the inventive genius of Hugill, Mr. Lemon rigged up an arrangement for drilling the well by water power (probably the first of its kind in the country,) and thus the hole was soon drilled to a considerable depth, or to something over 100 feet, as remembered by Mr. Albert Lemon (son of George S.,) where a flow of salt water, oil and gas was struck. This

was in 1844 according to Mr. Albert Lemon, and the oil rendering the salt water useless, the inventive talent of Hugill was again drawn upon. Through his assistance, Mr. Lemon perfected a siphon arrangement for automatically removing the water from the trough into which the well flowed, and in this manner about one barrel of oil was daily saved from the well, and added to the supply from the sand pits. This was termed "*sand oil*," and was fouud to command a price higher in the markets, by five cents per gallon, than the "*mud oil*" from the sand diggings. The well continued to flow about once daily for a considerable time, but whether it was ever pumped for oil or not, after it ceased to flow, the accounts are conflicting. It was located about 150 yards below the mouth of Flint Run, and the old timbers of the dam for water power, and the rocks between which the water turned the wheel may still be seen *in situ*, just under a modern well which now obtains its supply of oil from the upper portion of the "*Salt Sand*" at a depth of 600 feet.

Soon after Mr. Lemon had begun to market the oil from the pits and profits were accumulating therefrom, a question arose between him and Mr. Bushrod W. Creel concerning the title to the land on which the oil pits were situated. It appears to have been settled in favor of Mr. Creel, since we find his name on the books and records of the firm of Bosworth, Wells & Co., of Marietta, Ohio, as a seller of petroleum. A transcript from these old books which are in the possession of Mr. Tasker W. Bosworth, has been kindly furnished me by Mr. F. W. Minshall of Marietta, and as it possesses much of historic interest, is given herewith as follows :

Transactions in Petroleum of Bosworth, Wells & Co., Marietta, O., with Bushrod W. Creel, Hughes River, West Va.

Sales of Petroleum.

J. Schoonmacher, Pittsburg, Pa.

October, 1848,	Seneca oil	$ 149.00

H. G. Farrell & Co., Peoria, Ill.

October, 1848,	Seneca Oil	$ 89.95
July, 1849,	" "	168.00
Septem'r, 1850,	" "	230.00
Decem'r, 1855,	" "	1231.00

Canby & Hatch, Baltimore, Md.

1851,	Seneca Oil	$ 78.05

E. H. Stabler & Co., Baltimore, Md.

1851,	Seneca Oil	$ 161.00
December, 1857,	" "	3080.13

B. A. Fahnestock & Co., Pittsburgh, Pa.

May, 1849,	Seneca Oil	$ 120.00

Philadelphia, Pa., Sales.

1851,	D. Jayne & Son	$ 36.22
	Geo. D. Wetherell	155.00
	J. Gilbert & Co	70.00
	Samuel F. Troth & Co	15.00
	E. & C. Yarnell & Co	25.00
	Linn, Smith & Co	167.36
1860,	French, Richard & Co	1000.00

New York Sales.

1851,	Haviland, Harral & Risley	$ 190.00
	Joseph E. Trippe	71.00
	M. Ward & Co	350.00
1852,	Olcott, McKesson & Robins	55.35
	A. G. Bragg & Co	1804.00
	Haskill, Merrick & Bull	50.00
1854,	McKesson & Robins	394.00
1856,	Hall, Dixon & Co	731.00
	Thomas W. Clark	357.00
1857,	Scheiffelin Bros., & Co	130.00
	Barnes & Park	82.65

G. W. Westbrook	136.35
Babcock & Co	60.00

St. Louis, Mo., Sales.

April, 1852, Charless, Blow & Co	$ 306.80

Cincinnati, Ohio, Sales.

1853, Burdsall & Bros	$1507.00

Chicago Sales.

1855, E. M. Wells	$ 239.00
1856, " "	132.00

"The purchases from Bushrod W. Creel of Hughes River, W. Va., began in 1847, and continued regularly up to 1860. The price paid Creel from the beginning of the trade up to 1857, was 33 cents per gallon, delivered at Marietta. O. From 1857 to 1860 he was paid 40 cents per gallon.

The following entries taken from the credit side of the account with Mr. Creel, show the quantity purchased and the price at times named :"

January,	1855,	24	barrels,	at	33	cents	per	gallon.
May,	"	9	"	"	33	"	"	"
June,	"	29	"	"	33	"	"	"
July,	"	22	"	"	33	"	"	"
August,	"	32	"	"	33	"	"	"
September,	"	27	"	"	33	"	"	"
October,	"	29	"	"	33	"	"	"
December,	1857,	153	"	"	40	"	"	"
November,	"	72	"	"	40	"	"	"

There were, of course, petroleum sales from the Hughes river region, as well as from the Great Kanawha, to many other parties, but the transactions with Bosworth, Wells & Co., are the only ones yet discovered, of which a written record has been preserved. These records are of much historic interest, since taken in connection with the petroleum discoveries in the salt borings on the great Great Kanawha as early as 1808, as given by Dr. Hale, and those on the Muskingum, described by Dr. Hildreth in 1826, they show conclusively that a large (for the time) commercial business in petroleum was already in existence in Virginia and Ohio both from *drilled wells* and *sand pits*.

long before Col. Drake had completed (28th of August, 1859), near Titusville, Pa., the first well bored specifically for petroleum, and that, therefore, West Virginia should at least share with Pennsylvania the honor and credit of originating the great petroleum industries, and especially so in view of the fact that practically all well boring tools, methods of casing, drilling and pumping wells, were invented by citizens of what is now West Virginia.

Method of Pumping Several Wells from a Central Power Station, Invented by W. C. Stiles, Jr., of Volcano, W. Va.

The method of coupling several wells together and pumping all from one central power plant, thus enabling the producer to operate very small wells at a profit, was invented by the late Mr. W. C. Stiles, Jr., of Volcano, Wood county, W. Va., in 1874, and first applied in the Volcano field, where as many as forty wells were successfully operated by one engine under the superintendence of only one man. Mr. Stiles got the idea from seeing power transmitted by wire cables in Philadelphia, his former home, and his inventive genius successfully applied the same principle to the pumping of oil wells.

Drilling Operations of the Brothers Rathbone, at Burning Springs, on the Little Kanawha.

A small stream known as Burning Springs Run enters the right bank of the Little Kanawha river, 41 miles above the latter's mouth. The run was so named by the first settlers from the fact that natural gas came up in a sulphur or chalybeate spring, about one-half mile up the stream from its mouth, in such quan-

tity that it could be set on fire over a space of several feet square. There were two of these springs, one known as the "Big" spring, and the other as the "Little" one. These phenomena early attracted the attention of capitalists, and in 1842 the brothers Rathbone came to Parkersburg from New York, and soon after purchased a tract of land containing 1,000 acres covering the region along Burning Springs run, and including the springs themselves.

Salt was then one of the articles of commerce which on account of its scarcity, commanded a high price, and there was much profit in its manufacture. Because natural gas springs occurred on the Great Kanawha, Muskingum and in other localities where good brines had been found, the Rathbone brothers concluded it would be possible to find good salt producing brines on their 1,000 acre tract. Hence soon after the purchase was consummated, arrangements were made to sink a well for salt, and it was located on the left bank of the Little Kanawha, 100 yards below the mouth of Burning Springs run. At a depth of 250 feet so much oil was obtained (from the Cow Run or Dunkard Sand), that further attempts to find salt water were abandoned, and since the "gum" or conductor was left in the hole, the oil would rise to the top (as the hole was full of water) from which it was skimmed and sold. This old salt well was the first in the State to be pumped for oil alone, since soon after Col. Drake drilled his famous well near Titusville, Pa., the Rathbone salt well was leased and put to pumping. This was late in the fall of 1859, and it produced several barrels daily.

First Well Drilled for Oil in West Virginia.

The first well within the boundaries of the State, drilled solely for petroleum was also on the Rathbone tract, and located on Burning Springs run, a short distance (¼ mile) from its mouth. The well was drilled by the Rathbones and others from Parkersburg, and was begun late in the year 1859. Since the well was drilled with a "spring pole" it was not completed until about the 1st of May, 1860, when at a depth of 303 feet oil was encountered in the Cow Run or Dunkard sand, which produced at the rate of 100 barrels daily. The Rathbone tract was then sold to the Rathbone Oil Co. for a large sum, and the second well, finished by this Company late in the year 1860, came in at the rate of 40 or 50 barrels per hour at a depth of only 300 feet. These two wells brought the West Virginia oil territory into great prominence, and the developments followed so rapidly that the former village soon had a population of several thousand people, repeating the history of gold mining camps, and rich mineral discoveries in other regions.

Destruction of the Burning Springs Petroleum Industry.

At the height of this development in 1863. Gen. Jones of the Confederate forces appeared upon the scene, with his command of 3,000 cavalrymen, and setting fire to the oil accumulated in tanks, barrels and boats, destroyed in a day, it is estimated, not less than 300,000 barrels of oil, and effectually frightened away the northern capitalists who had invested their money in the Burning Springs field. The burned and abandoned wells became "water-logged," and the region

never recovered from the conflagration, although some oil is still produced there, and many wells have been drilled within the last few years.

Life of an Oil Well.

Two or three of the Burning Springs wells drilled in 1861 to the Dunkard or Cow Run Sand are still producing from one to two barrels daily, although 38 years old, and they never were large, thus showing that we do not yet know the maximum limit of life in an oil well.

Spread of Drilling Craze Over the State, and Failure of the Efforts to Reach the Oil Sands.

Soon after the Burning Springs oil development began, the petroleum craze spread all over the State. and large sums of money were paid by eastern capitalists for leases on tracts of land even far up in the mountain regions. Many wells were drilled in several counties, or at least attempts were made to drill them. which nearly always ended by getting the tools fast, and the hole plugged, because the operators had not yet learned the art of dealing successfully with rocks that crumble, or *cave*, and fall into the hole when water touches them. In the region of Titusville, Oil City, and all of north-eastern Pennsylvania the rocks (Sub-Carboniferous and Catskill) to be drilled through, are all hard and the walls of the wells stand firm after the holes are bored, even though drilled "wet" and full of water from top to bottom. but when the Pennsylvania drillers came down into West Virginia where a much higher and softer series of rocks was encountered (Permian and Coal Measures,) and attempted to use the

Pennsylvania methods, the result in most cases was failure to sink the borings to any of the Venango County oil producing sands. Thus it happened that the oil development of West Virginia outside of the Burning Springs and Volcano "oil breaks" or anticlinal, was delayed for 30 years behind that of her sister State on the north, for except along that bold arch between the Little Kanawha and Ohio rivers there was no oil production in commercial quantity until the year 1889. The region along the "Burning Springs—Eureka" anticlinal was practically all developed during the '60's, since here the soft rocks had been lifted into the air and eroded, so that Pennsylvania conditions existed, and it was possible to sink wells there without trouble from caving walls, hence the Burning Springs, White Oak, Volcano, Vaucluse, and other oil pools along this anticlinal had been developed, and practically exhausted before the new developments, inaugurated in 1889, had begun.

Recent Petroleum History of West Virginia.

The modern development of the petroleum interests of West Virginia, date from 1889. The old development which started at Burning Springs in May, 1860, had practically ended with defining the producing territory along the Burning Springs anticlinal, since although many "shows" of oil had been found in several other portions of the State during the drilling craze of the '60's, yet for the reasons already given, none of these attempts had reached the main oil producing sands of Pennsylvania, although it has since been proven that many of these early shallow borings, which, owing to the condition of the well drilling art

could be sunk only a few hundred feet, were in reality located over rich pools of petroleum or natural gas.

Statistics of Production.

The statistics of production in West Virginia are not perfect, especially for the early period of great development at Burning Springs, so that previous to 1876 the total for the State is merely an estimate. Subsequent to that date, the record is from the pipe line runs, and is, therefore, approximately accurate. These statistics are as follows, according to Oliphant in his Petroleum Reports for the U. S. Geological Survey :

1859 to 1876	3,000,000	barrels.
1876	120,000	"
1877	172,000	"
1878	180,000	"
1879	180,000	"
1880	179,000	"
1881	151,000	"
1882	128,000	"
1883	126,000	"
1884	90,000	"
1885	91,000	"
1886	102,000	"
1887	145,000	"
1888	119,448	"
1889	544,113	"
1890	492,578	"
1891	2,406,218	"
1892	3,810,086	"
1893	8,445.412	"
1894	8,577,624	"
1895	8,120,125	"
1896	10,019,770	"
1897	13,090,045	"
1898	13,603,135	"
Total	73,892,554	"

Great Increase in West Virginia Petroleum Output, Dating From 1889.

These tables exhibit an almost steady decline from 1876 until the close of 1888, but here the tide turns, and there is a sudden increase. The year 1889 marked the opening of the Dolls Run, Eureka, and Mannington oil pools, and from that time forward the growth of West Virginia's oil production has been upward with such marvelous strides that toward the close of the year 1898, it has finally surpassed that of Pennsylvania, and the pipe line runs at the present time (January, 1899), show that her production nearly equals that of Pennsylvania, New York, and the "*white sand*" district of Ohio, all combined. This primacy in "*white sand*" oil, (the purest and best petroleum in the world), production will also very probably continue in the future, since West Virginia, occupying as she does the heart or central portion of the great Appalachain coal basin, contains a much larger area of *white sand oil territory* than her sister states of Pennsylvania, Ohio, and Kentucky.

The year 1891 marked the maximum production (33,009,236 barrels) of the Pennsylvania field, 32 years after the industry began with the completion of the famous Drake well, and from that time (1892) forward the decline in Pennsylvania oil production has been rapid and almost continuous, so that in 1898, the pipe line runs from both the Pennsylvania and New York fields foot up only 15,232,702 barrels, only 1,629,567 barrels more than the West Virginia production.

The Future of West Virginia's Oil Production.

It is hardly possible that West Virginia's annual production can ever greatly exceed that of 1898, (13,603,135 barrels), and the probabilities are that from something near this figure it will gradually decline, since it is almost certain that the largest and richest pools of oil in the State have been discovered. There is some compensation, however, connected with the unpleasant fact of waning production, and that is, the price of petroleum is almost certain to advance with the diminishing supply, and hence it is possible that when the quantity produced has decreased to only one-fourth of what it is now, the price received then may be equivalent to that obtained now for the greater quantity.

Statistics of Production in Pennsylvania.

The statistics of oil production in our sister state of Pennsylvania, which are here given, constitute the strongest evidence of the limited supply of petroleum and are of themselves the most convincing argument that the stores of these precious hydro-carbons cannot last indefinitely. They read as follows according to Mr. Oliphant in Mineral Resources for the U. S. Geological Survey:

1859	2,000	barrels.*
1860	500,000	"
1861	2,113,609	"
1862	3,056,690	"
1863	2,611,309	"
1864	2,116,109	"
1865	2,497,700	"
1866	3,597,700	"

*These statistics also include the small oil production from the State of New York.

LIBRARY OF THE UNIVERSITY OF CALIFORNIA

1867	3,347,300	"
1868	3,646,117	"
1869	4,215,000	"
1870	5,260,745	"
1871	5,205,234	"
1872	5,293,194	"
1873	9,893,786	"
1874	10,926,945	"
1875	8,787,514	"
1876	8,968,906	"
1877	13,135,475	"
1878	15,163,462	"
1879	19,685,176	"
1880	26,027,631	"
1881	27,376,509	"
1882	30,053,500	"
1883	23,128,389	"
1884	23,772,209	"
1885	20,776,041	"
1886	25,798,000	"
1887	22,356,193	"
1888	16,448,668	"
1889	21,487,435	"
1890	28,458,208	"
1891	33,009,236	"
1892	28,422,377	"
1893	20,314,513	"
1894	19,019,990	"
1895	19,114,390	"
1896	20,584,421	"
1897	19,262,066	"
1898	15,232,702	"
Total	571,666,449	"

Meaning of Fluctuation in Production.

The fluctuations shown in this production mark the rise and decline of great oil pools, like Bradford, Cherry Grove, Washington and McDonald, the last great pool pool discovered in Pennsylvania, which carried the production of that State to its maximum in 1891, from which it has steadily declined, and will in the nature of things continue so to do, with temporary spurts of

increase from the discovery of new producing areas. The drill has now exploited the possible oil territory of Pennsylvania so thoroughly, however, that it is hardly probable any large areas of richly productive territory yet remain to be discovered that can materially increase, or even stay the present declining yield of petroleum in that State.

The same condition of affairs which these statistics reveal as a reality in Pennsylvania must in the near future occur in West Virginia as above stated, if they are not already here. The work of exploitation is now carried on so much more vigorously and rapidly than was possible a few years ago, that it is probable, no perceptible future increase can be made in West Virginia's oil production, in fact it is barely possible that the year 1898 will mark the maximum output of the field, and that the inevitable decline has already begun, unless indeed some large producing areas shall yet be found south-west from the Little Kanawha river, for which there is yet but little reason to hope as will be shown in a succeeding chapter.

Natural Gas.

Along with this wonderful recent growth of the petroleum industry in West Virginia there has been a corresponding increase in the production of natural gas, so that this State now stands first of all the States of the Union in the production of this matchless fuel, and with proper care in husbanding this source of power and the prevention of needless waste it should last for another generation at least.

Nearly all the principal towns of the State west of the Alleghanies are now supplied, or about to be sup-

plied with this fuel, while the Pittsburg region receives many million feet daily through the great 16-inch line of the Philadelphia Company which, crossing through the immense gas fields of Wetzel county, extends down into the central portion of Tyler. The Tri-State Gas Company is supplying Steubenville and many other Ohio towns from West Virginia. The Wheeling Natural Gas Co., the Mountain State Gas Co., and others have extensive plants, while the Carnegie Company, which consumes in its various iron and steel works at Bessemer, Duquesne, Homestead and Pittsburg, thirty to fifty million cubic feet daily, has let the contract for an extension of its lines into West Virginia territory. The hundreds of drilling wells, and thousands of pumping oil wells, and all of the pipe lines for handling the oil produced within the State, the water supply, and everything connected with the oil industry, receive practically all of their power from the consumption of natural gas, and the quantity thus burned in useful work must run into many millions of cubic feet daily, probably not less than two hundred millions, while the amount wasting into the air from oil wells, and safety pressure valves of the pipe lines is probably as much more.

THE GEOLOGY OF PETROLEUM AND NATURAL GAS.

Method of Occurrence.

Many people who are uninformed on the subject, imagine that both petroleum and natural gas occur in immense caverns, or hollow spaces within the earth's crust. Hence when one speaks of a "pool" of oil or gas the image of an underground lake or great cavity filled with nothing but liquid oil, or highly compressed gas, is called up to the minds of such persons as are unfamiliar with the oil industry. This is a great mistake, for with the exception of narrow fissures and joints which traverse all rocks, there are no large cavities or open spaces in any of the West Virginia oil producing strata. But all rocks are *porous*, even slate of the closest grain will hold some liquid in the minute and microscopic cavities which it, in common with all rocks, contains. Now the oil and gas *sands* are simply very *porous rocks* which contain not one great cavity, but millions upon millions of small or microscopic cavities, so that the oil, gas, water, or all three together, it may be, (as at Sistersville,) occupy these numerous little spaces, and thus *saturate* the rock just as water does a piece of cloth or a sponge when dipped into the same. The larger these pores are, and the greater the volume they occupy in proportion to the volume of the rock mass, the greater will be the contained oil or gas supply, and this proportion in fairly good produc-

ing sands, usually varies between one-fifth and one-tenth, that is, a cubic foot of rock would hold, say, 6 to 12 pints of oil, and of course would contain an equal volume of cavities for water or gas should either of these substances be present, instead of oil.

Quantity of Petroleum to the Acre.

It is probable that the amount of oil obtainable from good producing sand will not average more than a gallon to the cubic foot, and also that the depth or thickness of "*pay streaks*" (porous sand saturated with oil) will not average more than five feet, and taking these factors as a basis, (there being 43,560 square feet in one acre,) we would get about 5,000 barrels of 42 gallons each as the total production of fairly good oil territory. Of course, if the sand reservoir should be exceptionally thick and of very great porosity, like a mere bed of loose gravel, this estimate may be much exceeded over limited areas, but the amount named is a fair average for what would be considered good producing territory, and may be regarded as approximately correct in figuring roughly the prospective values of developed properties. True, the conservative operator will always leave a safe margin on the right side of his valuation, in a business where there are so many contingencies, not only in varying thickness and porosity of the sand, but also in the price for his product which fluctuates within wide limits, and often within very short periods, but with the acreage estimate of production as a guide, investments may be made in developed oil properties quite as safely as in most other forms of property, and generally with a much greater margin of profit.

Not Possible to Obtain All the Oil Present.

It is impossible that all of the oil in any sand can be gotten out by the ordinary process of drilling wells into the same, and probably one-fourth of the actual amount present will remain in the rock, held there by capillary attraction, which neither the accompanying gas, nor the attraction of gravity can overcome. The only manner in which this oil could be obtained would be to mine, crush and boil the sand, as was formerly done at Pechelbronn, Germany, from 1742 until 1880, where 4 to 5 per cent. of petroleum was procured from the rock by such treatment.

The Presence of Salt Water Increases Proportion Obtained.

When *salt water* is found in connection with the oil as in the "Hundred Foot" district of Butler county, Penna., or the Sistersville field of West Virginia and Ohio, most operators consider that a much greater proportion of the oil can be secured than where the salt water is absent, since the water acts as a rinsing fluid to flush the petroleum out of the sand and bring it freely into the well. It is also claimed by the practical oil producers that the tendency of the rock to become clogged up with parrafine is much less when the petroleum is accompanied with salt water than when it is absent, so that for both of these reasons it is most probably true that the sand will yield up a greater proportion of its oil, when the latter is accompanied by salt water. Whether or not the increased yield will equal the increased cost of pumping the additional fluid (salt water) to the surface, is a question upon which we have as yet no reliable statistics.

Aids in Locating Oil and Gas Pools.

These questions have been very frequently asked by the petroleum seekers, "Can anything be done to limit the number of failures in the search of oil and gas?" Are there any surface indications which can be relied upon to indicate the presence or absence of oil and gas in paying quantity at a depth of several hundred, or perhaps several thousand feet under ground? Cannot science with all her resources discover some means of saving a large portion of the hundreds of thousands of dollars that are annually lost in drilling unproductive wells?

What answer does *geology* give to these questions which have been asked every day since Col. Drake drilled the first well for oil in 1859?

Geology answers that by careful attention to her precepts, *much* of the waste that characterized the first three decades of the search for petroleum can be avoided, but that it is beyond her powers to foretell absolutely as to whether any particular boring will yield either oil or gas in commercial quantity. The careful geologist can eliminate many of the factors of uncertainty, and thus limit the search to regions having a peculiar geological structure where experience has shown that the occurrence of oil and gas is most probable, but further than this, geology cannot go, and no skillful geologist has ever claimed otherwise.

The history of opinion upon this subject is of especial interest to the citizens of a state like West Virginia within whose boundaries so many millions of dollars have already been expended in the search for oil and gas, and where so many millions more will be expended in the future.

We may dismiss the attempts to locate oil and gas pools with the "divining rod," "magnetic devices," 'spirit media," etc., all of which have found credulous victims in the past, but very few in recent years, with only this passing notice of their existence, and come down to the decade beginning with 1880. This decade will ever be memorable in the history of the Appalachian region, as marking the modern rise and culmination of natural gas production for use in the great manufacturing concerns of the Pittsburg region.

History of the Structural or Anticlinal Theory.

When the importance of natural gas to industrial affairs had been fully recognized, and the producers of oil had begun to turn their attention to the search for the new fuel, it was to be expected that some attention would be given to the study of its occurrence.

The first oil producer to undertake this study in a systematic way, was Mr. J. J. Vandergrift, of Pittsburg, Pa., then President of the Forest Oil Co., and the United Pipe Lines.

In the spring of 1883, Mr. Wm. A. Earseman, a veteran oil operator, who was then in the employ of the Anchor Oil Co., and who had noted the fact that many of the great gas wells of Pennsylvania were located along the lines where *anticlinal axes* had been drawn on the maps of the State Geological Survey of Pennsylvania, secured Mr. Vandergrift's assent and financial support to undertake a geological investigation of the occurrence of natural gas. Mr. Earseman then began a correspondence with myself upon the subject, the result of which was an engagement in which the writer agreed to devote the month of June, 1883, to an inves-

tigation of the subject for Mr. Vandergrift. In this work I was often accompanied by Mr. Earseman, who communicated freely to me his ideas on the subject of anticlinals, though he did not then possess the necessary geological attainments to enable him to verify or disprove his suspicions. After visiting and studying the geological surroundings of all the great gas wells that had been struck in the Appalachain district, the conclusion was reached that the rock disturbance caused by anticlinal waves was the main and important factor in the occurrence of both petroleum and natural gas, and this announcement was made to Mr. Vandergrift in a written report at the close of June, 1883. During the next two years the theory was submitted to several practical tests in the successful location of the Grapeville, Washington, and other great gas pools. Having thus verified the hypothesis, it was duly formulated, and given to the public through the columns of "Science" in an article entitled "The Geology of Natural Gas," by I. C. White, in the issue of that journal dated June 26th, 1885.

Since there have been many inquiries for this paper from those interested in petroleum, which it has been impossible to supply, the article in question is republished here together with my discussion of the subject in other journals, which the original publication provoked. The statement in "Science" of June 26th, 1885, reads as follows :

The Geology of Natural Gas, by I. C. White.

"The recent introduction of natural gas into general use as a source of heat for industrial and domestic purpose has raised it from the rank of a mere curiosity to one of the earth's most valuable treasures.

"To the reader unacquainted with the change natural gas has effected in

all industries where it can be obtained, the following quotation from an article in *MacMillan's Magazine* for January, written by Mr. Andrew Carnegie, the chief iron master of Pittsburg, will be a revelation: 'In the manufacture of glass, of which there is an immense quantity made in Pittsburg, I am informed that gas is worth much more than the cost of coal and its handling, because it improves the quality of the product. One firm in Pittsburg is already making plate glass of the largest size, equal to the best imported French glass, and is enabled to do so by this fuel. In the manufacture of iron, and especially in that of steel, the quality is also improved by the pure new fuel. In our steel rail mills we have not used a pound of coal for more than a year, nor in our iron mills for nearly the same period. The change is a startling one. Where we formerly had 90 firemen at work in one boiler house, and were using 400 tons of coal per day, a visitor now walks along the long row of boilers and sees but one man in attendance. The house being whitewashed, not a sign of the dirty fuel of former days is to be seen; nor do the stacks emit smoke. In the Union iron mills our puddlers have whitewashed the coal-bunkers belonging to their furnaces. Most of the principal iron and glass establishments in the city are today either using this gas as fuel or making preparations to do so. The cost of coal is not only saved, but the great cost of firing and handling it; while the repairs to boilers and grate-bars are much less.'

"This new fuel, which bids fair to replace coal almost entirely in many of our chief industrial centers, has not received that attention from the geologist which its importance demands. So far as the writer is aware, nothing has been published on the subject which would prove of any value to those engaged in prospecting for natural gas, and it is the existence of this blank in geological literature that has suggested the present article.

"Practically all the large gas wells struck before 1882 were accidentally discovered in boring for oil; but when the great value of natural gas as fuel became generally recognized, an eager search began for it at Pittsburg, Wheeling, and many other manufacturing centers.

"The first explorers assumed that gas could be obtained at one point as well as at another, provided the earth be penetrated to a depth sufficiently great; and it has required the expenditure of several hundred thousand dollars in useless drilling to convince capitalists of this fallacy, which even yet obtains general credence among those not interested in successful gas companies.

"The writer's study of this subject began in June, 1883, when he was employed by Pittsburg parties to make a general investigation of the natural gas question with the special object of determining whether or not it was possible to predict the presence or absence of gas from geological structure. In the prosecution of this work I was aided by a suggestion from Mr. William A. Earseman, of Allegheny, Pennsylvania, an oil operator of many years experience, who had noticed that the principal gas wells then known in western Pennsylvania were situated close to where anticlinal axes were drawn on the geological maps. From this he inferred there must be some

connection between the gas wells and the anticlines. After visiting all the great gas wells that had been struck in western Pennsylvania and West Virginia, and carefully examining the geological surroundings of each, I found that every one of them was situated either directly on or near the crown of an anticlinal axis, while wells that had been bored in the synclines on either side furnished little or no gas, but in many cases large quantities of salt water. Further observation showed that the gas wells were confined to a narrow belt, only one-fourth to one mile wide, along the crests of the anticlinal folds. These facts seemed to connect gas territory unmistakably with the disturbance in the rocks caused by their upheaval into arches, but the crucial test was yet to be made in the actual location of good gas territory on this theory. During the last two years I have submitted it to all manner of tests, both in locating and condemning gas territory, and the general result has been to confirm the anticlinal theory beyond a reasonable doubt.

"But while we can state with confidence that all *great gas wells* are found on the anticlinal axis, the converse of this is not true, viz., that *great gas wells* may be found on all anticlinals. In a theory of this kind, the *limitations* become quite as important as, or even more so than the theory itself; and hence I have given considerable thought to this side of the question, having formulated them into three or four general rules (which include practically all the limitations known to me, up to the present time, that should be placed on the statement that large gas wells may be obtained on anticlinal folds), viz:

(a) "The arch in the rocks must be one of considerable magnitude.

(b) "A coarse or porous sandstone of considerable thickness, or, if a fine grained rock, one that would have extensive fissures, and thus in either case rendered capable of acting as a reservoir for the gas, must underlie the surface at a depth of several hundred feet (500 to 2,500.)

(c) "Probably very few or none of the grand arches along the mountain ranges will be found holding gas in large quantity, since in such cases the disturbance of the stratification has been so profound that all the natural gas generated in the past would long ago have escaped into the air through fissures that traverse all the beds.

(d) "Another limitation might possibly be added, which would confine the areas where great gas flows may be obtained to those underlain by a considerable thickness of bituminous shale.

(e) "Very fair gas wells may also be obtained for a considerable distance down the slopes from the crests of the anticlinals, provided the dip be sufficiently rapid, and especially if it be irregular or interrupted with slight crumples. And even in regions where there are no well marked anticlinals if the dip be somewhat rapid and irregular, rather large gas wells may occasionally be found, if all other conditions are favorable.

"The reason why natural gas should collect under the arches of the rocks is sufficiently plain, from a consideration of its volatile nature. Then, too,

the extensive fissuring of the rock, which appears necessary to form a capacious reservoir for a large gas well, would take place most readily along the anticlinals where the tension in bending would be greatest.

"The geological horizon that furnishes the best gas reservoir in western Pennsylvania seems to be identical with the first Venango oil sand, and hence is one of the Catskill conglomerates. This is the gas rock at Murraysville, Tarentum, Washington, Wellsburg, and many other points. Some large gas wells have been obtained in the Sub-carboniferous sandstone (Pocono,) however, and others down in the third Venango oil sand. (Chemung.)

"In Ohio, gas flows of considerable size have been obtained deep down in the Cincinnati limestone, while in West Virginia they have been found in the Pottsville conglomerate; hence natural gas, like oil, has a wide range through the geological column, though it is a significant fact that it is most abundant above the black slates of the Devonian."

The conclusions announced in the foregoing article were criticised by Mr. Charles Ashburner, geologist in charge of the geological survey of Pennsylvania, who claimed, in effect, that the relation between gas wells and anticlinals was one of coincidence merely, or of the same nature as Angell's "belt theory" of oil, and also that large gas wells could be found in synclines.

To this criticism the writer published the following reply in *Science*, of July 17, 1885:

"In reply to Mr. Ashburner's criticism of the views advanced in my article on natural gas, I would say that the necessary brevity of the paper in question prevented the mention of many facts that might have rendered the conclusions clearer and less open to challenge. One of these is that my communication had especial reference to the natural gas regions proper, *i. e.*, where the gas is unconnected with the oil fields. Most geologists know that natural gas in large quantities exists with and contiguous to every oil pool, apparently as a by-product in the generation of the oil, and of course the rocks are filled with it wherever it can find a reservoir. To gas wells from such sources Mr. Ashburner's criticism may sometimes be found applicable; but, even with these, by far the larger ones will be found on the arches of the rocks.

"The cases that Mr. Ashburner mentions, where large gas wells have been found at the centers of synclines, do not necessarily contradict my conclusions; for no one knows better than he that a subordinate crumple or anticlinal roll often runs along the central line of a syncline.

"My excuse for writing the article on natural gas was that I might be of some service in preventing the waste of capital that has been going on within a radius of fifty miles of Pittsburg by an indiscriminate search for natural gas; and it is a sufficient answer to Mr. Ashburner's criticism to point him to the brilliant lights along the crests of the Waynesburg, Pinhook, Washington, Bull Creek, Bradys Bend, Hickory, Wellsburg, Raccoon, and other anticlinals, and also the darkness that envelops the intervening

synclines, in which hundreds of thousands of dollars have been invested without developing a single profitable gas well. The same result has been proven in other portions of the country. The Great Kanawha Valley above Charleston has been honeycombed with borings for salt, and the only gas wells developed were found within a belt a few rods wide, which coincides with the crest of the Browntown anticlinal, where immense flows were struck. In this connection I should say that Col. Allen, of Charleston, says he can trace the Browntown anticlinal by the escaping gas across streams, and even mountains, from the Kanawha river to the Big Sandy, where, on its crest, near Warfield, two of the largest gas wells ever known have recently been struck. At Burning Springs, on the Little Kanawha, the only large gas wells were found on the very crest of the great uplift in that region. The gas belt of western Ohio, through Findlay and other towns, follows closely the line of the Cincinnati arch, and the same story is repeated in other localities too numerous to mention.

"Mr. Ashburner can, if he chooses, interpet these facts as mere coincidences, and explain them to himself as having no more bearing on the question of finding gas than "Angell's belt theory" of oil; but the practical gas operator can no longer be deluded by such logic into risking his money in water-holes (synclines) where so many thousands have been hopelessly squandered.

"With regard to the anticlinal theory not being 'a practical basis for successful operations,' I deem it a sufficient reply to state that all the successful gas companies of Western Pennsylvania and West Virginia are getting their gas from the crests of anticlinal axes, while those that have confined their operations to synclines have met with uniform financial disaster.

"The statement was distinctly made in my original communication that gas would not be found on all anticlinals, nor at all localities along one that actually produces gas, since other factors have to be considered, as there stated; but, with the facts before us, it would certainly prove a great saving of capital in the search for gas if operations were confined to the crests of anticlinals, and I fail to perceive how Mr. Ashburner's fears for the 'misleading' character of my article can be realized."

Mr. Ashburner replied to this in *Science* of September 4, 1885, and has written further on the subject in a paper read before the American Institute of Mining Engineers, Halifax meeting, 1885, and also in *The Petroleum Age* for January, 1886. As a general reply to these strictures and also to illustrate the theory more fully, the writer prepared a paper for *The Petroleum Age* which was published in the March number of that journal, along with a map of western Pennsylvania, on which were located the principal anticlinal lines, and also the large gas wells. Since the article in question contains several points of interest not hitherto given to the public, the principal portion of it is here republished, without the map, which can be procured from *The Petroleum Age* by any reader who wishes it for reference:

"Where the anticlinal lines are drawn full on that map they represent

actual observations of myself or others, but the dotted lines are projections of arches observed only at a few points ; for instance, Mr. Ashburner states that the Sheffield gas wells are on the crest of an anticline, and when the Martinsburg axis of Mr. Chance is projected approximately parallel to the others, it passes through the Sheffield region ; hence the two are assumed to be identical, and the same principal has been followed in making the other projections.

"There are probably other flexures in the rocks which traverse the district in question that, in the rapid survey made of some of the counties, were not detected by the assistant geologists of the Pennsylvania survey. The writer pleads guilty to some mistakes of this nature, as well as of getting one anticlinal confused with another, in the case of the Fredericktown uplift. This mistake which was corrected by Mr. H. Martyn Chance, in report V, may possibly have been duplicated by others of the assistants before they became expert at detecting minute changes in dip or stratification.

"An inspection of the accompanying map will reveal the fact that the main north-east and south-west anticlinals are cut by another set at nearly right angles, which have been termed cross-cut anticlinals. To Mr. Ashburner belongs the credit of first calling the attention of geologists to this feature in the rock structures of Pennsylvania, and the great Kinzua-Emporium cross.cut wave which he first traced through Cameron, Elk and McKean counties is shown on the present map.

"The surveys of the Western counties of Pennsylvania were practically finished before the publication of Mr. Ashburner's observations in the northern portion of the State, and hence although similar phenomena were observed they were not described in similar terms or referred to similar causes. Thus, Stevenson (as well as Rogers long ago) recognized a great bulge in the Chestnut ridge uplift, near Uniontown, by which the Hamilton rocks are elevated to the summit of the mountain, but the arch dying down both north and south, the Catskill rocks fail to reach the surface where the axis crosses the gorge of Cheat river in the one direction, and the Chemung beds are completely buried at the Conemaugh gap in the other.

"During the last two years the writer has given considerable thought to these cross-cut axes, and the results show that a cross-cut anticlinal (presumably identical with the one crossing Chestnut ridge near Uniontown) goes through the famous Cannonsburg and Hickory gas regions in Washington county, while another parallel to it, and a few miles west, goes through the village of Pinhook, or Lone Pine, and also cuts the McGuigan gas field.

"Another of marked extent has recently been traced by the writer through the Murraysville and Grapeville region of Westmoreland county, the greatest gas field in the world, so far as the present developments show. Groups of wells also appear to cluster along the grand arch that Mr. Ashburner has traced through northern Pennsylvania.

"Having observed the importance of these cross-cut arches in the loca-

tion of gas territory, I wrote Mr. Ashburner, suggesting that there might be some disturbance of the rocks in the region of Kane, where he claimed large gas wells were found in an undisturbed syncline.

The recent discovery of oil in the Kane region has led to the drilling of many wells, and in the *Oil City Derrick* of a recent date, the statement is made on the authority of Mr. McKinney, of the Union Oil Company, that a rapid northward dip has been found, *i. e.*, a subordinate cross-cut anticline parallel to the main one north of Kane passes through the Roy and Archer gas region. Whether this shall turn out true or otherwise, there is certainly no inherent improbability against finding such subordinate waves.

"Very unexpected and surprising was the testimony on this head which came from Mr. L. R. Curtiss, of Mendota, Illinois, who, unknown to myself, made a careful study of the conditions under which natural gas occurs in that State, and reached the same conclusions quite independently of my own views, as will be seen from the following paragraphs, quoted by permission from his letter to me on the subject:

"'The principal anticlinal axis of Illinois puts out in Ogle county, in the northern part of the State, and extends in a direction S. 20° E. through La Salle and Champaign, and thence to Coles and Clark counties, in the southeastern part of the State. Along this axis natural gas can be traced in springs and well borings for a distance of 160 miles. *It is, however, more prevalent on the crowns of the cross axes.* This is notably the case at Mendota, where the cross-axis intersects the main anticline at an angle of 85° (running S. 65° W.), and on the summit of this fold the gas belt extends south-westward into Bureau county for over twenty-five miles. The other cross-axes located further to the south intersect two or three low anticlinals toward the Mississippi, and tend in the direction of the gas fields in McLean, De Witt, Macon and Montgomery counties.'

"This same story is repeated in Ohio, according to the testimony of the eminent state geologist, Professor Orton (see his letter in *Ohio State Journal* of recent date.)

"Now what is the effect of these cross-cut axes on geological structure? Evidently one effect would be to cause the arches and corresponding troughs themselves to rise or sink, as we approach or recede from the cross-cut as the case may be; for example, the general rule is that the rocks of western Pennsylvania dip down to the southwest along the line of the anticlinals, as well as away from them (N. W. and S. E.), but in the region of Cannonsburg this rule is reversed and the rocks *rise* rapidly (seventy-five feet per mile) to the south-west along both anticlinals until the crest of the Hickory-Houstonville cross-cut arch is passed, when a rapid *dip* begins in the same direction (south-westward), thus forming at the points of intersection a kind of "hog-back" structure (as Mr. Earseman terms it) from which the rocks dip away in every direction.

"Hence these cross-cut arches result in carrying the anticlinal structure and a line of disturbance in the rocks directly across the trend of a syncline, and failure to grasp this fact is the principal reason why Mr. Ash-

burner insists upon his readers believing that a great gas well may be obtained in a syncline; for it is quite certain that no large gas well has ever yet been found in the trend of a cyncline, except where the trough itself has been elevated by a long rise from the south-west, which is, of course, brought about by the cross-cut folds.

"These are the geological surroundings of all those wells which Mr. Ashburner cites from northern Pennsylvania and southern New York as occurring in synclines. It is not necessary to show a reversed or north-east dip in order to demonstrate the existence of one of those cross-cut waves, since their crests are (like some of the main north-east and south-west anticlinals) often marked by a simple flattening of the rate of dip along the latter. Professor Orton would call such a structure (where there is no reversal of dip, but only a change in rate) a *suppressed anticlinal*, a very good name, for such it really is.

"It follows, of course, that a cynclinal structure may be converted into an anticlinal one by the presence of the cross-cut wave, so the reverse may and frequently does happen, of which we have a notable instance in the region immediately adjoining Pittsburg. Here the anticlinals all sink down toward the south-west until we reach the bottom of a cross-cut trough, where they begin to rise again toward Cannonsburg, the result of which is to flood all the porous rocks under Pittsburg with salt water. The numerous wells drilled at Pittsburg show a good reservoir (Mr. Ashburner's prime factor for gas wells); but geological structure dominates here as everywhere else, and fills the reservoir with water, so that the little gas obtainable is practically useless, though when structure has elevated this reservoir out of the water at Tarentum on the north and Cannonsburg on the south, gas is obtained in abundance.

"Another cross-cut anticlinal passes along the Conemaugh river, intersecting Leechburg and Butler, its path being marked by a line of gas wells across synclinals as well as anticlinals.

"Having now glanced at some of the general structural features under which large gas wells are found, we shall consider a few of the individual arches and troughs in order to illustrate some of the general principles to which reference has been made.

"*Laurel Hill and Chestnut Ridge Anticlinals.*—The arches made by these great axes would, in my opinion, come under the ban of exception (a), and hence the rocks would probably be fissured too much to retain large quantities of gas. This is only an inference from theory, however, since so far as I am aware only one or two wells have been bored near the crown of either arch. One of these was bored for oil in Monongalia county, West Virginia, where the Chestnut ridge axis crosses Decker's creek, six miles south-east of Morgantown. This well began at the base of the No. XI limestone and descended about 400 feet, and hence did not penetrate the great Murraysville gas horizon (first Venango oil sand). Whether or not these large arches may furnish gas when they have flattened out to much lower waves in northern Indiana and Cambria counties is a question that only the drill

can settle, though the fact that some gas was obtained at Cherry Tree, near the Nolo anticlinal (between Laurel Hill and Chestnut ridge), would seem to render the hope not entirely groundless. In fact it is within the range of possibility (though not probable) that if a hole were sunk to a great depth on these arches, where they exhibit even a large development, gas might be found. The drill has this question to settle yet, since the two deep wells drilled in the synclines at Johnstown and Wellersburg could not be expected to find gas. Those drilled in the Ligonier Valley were also in a syncline, and hence obtained only small quantities of gas.

"Coming still further westward we find that several well shave been bored along the western slope of Chestnut ridge, about half way down the dip from the crown of the arch. One of these on Decker's creek and two on Cheat river, West Virginia, found a considerable quantity of gas in No. XII (the first great gas horizon), but the rock as might have been expected, was filled also with water, which rendered the gas useless. The wells bored under nearly the same conditions as to locations in Westmoreland county found very little gas.

"The next arch westward from Chestnut ridge is the Indiana axis of Platt. This is a very sharp and well defined wave in Westmoreland county, the vertical distance from the crest to the bottom of the troughs on either side being in some places not less than 800 feet or even more; hence, unless its proximity to the great arch of Chestnut ridge should affect it, we would on 'the anticlinal theory,' naturally expect it to furnish good gas wells, provided the proper kind of reservoirs exists under the surface. Messrs. Guffey and Mellon have recently finished a well on this arch near Latrobe, which yields from five to six hundred thousand feet of gas daily. Some drilling was once done in the vicinity of Blairsville, where the arch crosses the Conemaugh river, but no large flow of gas was obtained, probably because the well was situated too far from the crest of the arch.

"Going still farther north-eastward we find the well which supplies the town of Punxsutawney with gas is situated close to this fold.

"The next arch is the great Saltsburg axis of Stevenson, the descent on each side of which is quite as great as that of the Indiana arch. This is far enough away from the Chestnut ridge disturbance to remain unaffected by the latter, and hence ought to furnish a fair test of the 'anticlinal theory.' The writer recently located a well on this arch for J. M. Guffey & Co., just north from the town of Grapeville, and when the Murraysville sand was reached a few weeks ago an immense flow of dry gas was struck.*

* "Since this was written two other wells have been drilled to the Murraysville sand, on the crown of the Saltsburg arch, near Grapeville, and competent judges who have seen all the great gas wells in the country, pronounce them much the largest that have ever yet been struck; so that my prediction of three years ago, that the Grapeville region would furnish larger wells than the Murraysville, has been literally fulfilled. This conclusion was based on *geological structure* alone, since the Grapeville, or Saltsburg arch, is a much grander one than the Murraysville fold. Can Mr. Ashburner explain this away as a case of coincidence of the Angell "belt theory" kind?

"Some gentlemen from Greensburg, however, who like Mr. Ashburner, seemed to think gas could be obtained in a syncline, drilled a well one mile east from the crest of the arch, at a locality where the dip had carried the rocks down 250 feet below the crest of the Saltsburg wave. The result was that although a splendid reservoir of great thickness was found, it contained an immense supply of water, and consequently what little gas was obtained was worthless. These wells, the one furnishing a large *gas* flow and the other a large *water* flow, are only two and one-half miles apart, the former on the crown of the arch, the latter nearly a mile east from the same. No fairer test than this could be asked for the merits of the 'anticlinal theory.'

"The next arch westward is the *Waynesburg axis*, and the only gas wells obtained along the Monongahela river, among the many that have been bored, are found on its crest at Bellevernon, though the fold being low and flat, no large wells have been struck.

"The great Murraysville arch was regarded by Professor Stevenson as identical with the Waynesburg fold, the latter having been shifted eastward; but, however this may be, there is no doubt about the one dying away to the north and the other to the south, and hence I have termed the western fold simply the Murraysville axis. This, like many other well known arches in Pennsylvania, is a double fold, with the crests about one-half mile apart, though the depression between them is very slight. As every one knows, the forty or more great gassers in that region are clustered along the Murraysville anticlinal, water being obtained in the synclinal at Irwin on the east and at Walls on the west. 'But,' says the opponent of the 'anticlinal theory,' 'you get water with the gas even along the Murraysville arch when you come south of the Pennsylvania railroad; hence of what account is the theory, anyhow?' 'My critical friend,' we answer, 'you have not observed wisely, else you would have seen that the Murraysville arch dies down and flattens out very rapidly into the great cross-cut syncline trough which embraces the city of Pittsburg, and a broad belt on either side, and the 'anticlinal theory' of gas teaches that it is quite as unwise to expect large gas wells on an arch so situated structurally as in a genuine syncline; for whenever the dip along the axial line begins to equal or surpass the total height of the wave, water may be confidently expected.' Hence, although some very large flows of gas have been struck near where the Murraysville arch crosses the Youghiogheny river, yet the quantity of water in the rock was so great that the gas was soon drowned out. The same principle accounts for the water in the Venice well of Washington county, which is located near the structural line of the Bradys Bend axis, and so of others that have been pointed to as contradicting the 'anticlinal theory.' And thus we might go over the entire list of anticlinals; but as the story would be practically the same everywhere, it is useless to tire the readers' patience with details. It has been shown that the great gas wells cluster along the anticlinals, and where any marked exception to this rule occurs we find a cross-cut arch is the disturbing cause, and hence the seeming conflict is the strongest confirmation of the real essence of the 'anticlinal theory,' which,

condensed and simplified into the fewest words, means that *structure* is the main factor in a search for great gas wells ; that *disturbance* in the rocks by which they have been elevated above the same beds in contiguous regions, either on the crest of an anticlinal arch or along the axial lines of the synclines themselves (where cut by the cross-arches) is an essential element in finding large and lasting wells, free from water, and, therefore, entitled to be called 'great.'

"It is true that a considerable quantity of gas may be so shut in by close rock (through which it cannot pass) as to be imprisoned even in a syncline, and when first struck may deliver a large quantity of gas, and the same may be true where the rocks are nearly horizontal, especially in regions contiguous to oil territory ; but such wells soon blow themselves out and cease to deliver gas, like the famous 'Mullen Snorter' and 'Kane Geyser,' which figure so largely in Mr. Ashburner's criticism of the 'anticlinal theory.'

"Reference has also been made to the gas wells at Erie and Fredonia as evidence against the 'anticlinal theory,' since it is claimed there are no anticlinal waves near these localities. To any one who deems these wells evidences against what I have claimed for the 'anticlinal theory,' I must request him to read more carefully the quotations from my original paper found in this article, where he will not find the statement that *all* gas wells occur on anticlinals, but instead, all *great* gas wells are found close to anticlinal arches. Now what is a 'great well?' It is probable that no gas well yet struck ever delivered more than thirty to thirty-five million cubic feet of gas daily. Some have been measured in the Murraysville field that, if we can believe the figures, have yielded thirty-three million feet daily. This is one extreme ; but certainly by no stretch of language could the term 'great' be applied to wells like those of Erie, Fredonia and elsewhere along Lake Erie, which, according to Professor Orton's measurements, yield only from twenty to sixty thousand feet daily.

"Moreover, so far as Erie is concerned, a recent and careful study of the stratification there has revealed to the writer the presence of low waves in the same, approximately parallel to the lake, which were undetected in the necessarily hasty examination made several years ago for the Pennsylvania geological survey.

"As everyone knows, it is scarcely possible to penetrate the earth to a considerable depth anywhere within the Paleozoic area (except the rocks are highly contorted) without getting some natural gas, but the *large* supplies are confined to restricted areas, and it was to prevent the waste of capital in an indiscriminate search for these great stores of valuable fuel that prompted my original article on the subject. The drill will, of course, finally settle the question as to whether or not my conclusions were valid. Something, however, has already been accomplished in this line.

"A map of Ohio would reveal the same condition of affairs, for there are only two or three prominent anticlinals in the state, and after the expenditure of a vast amount of money in drilling, the only large gas wells have been found along these lines of *disturbance*. Kentucky, Illinois and West

Virginia tell the same story; so that there would seem to be no good reason for any one longer to doubt that *structure* is the great factor in securing large and lasting gas wells.

"If, however, some skeptical capitalist shall ever find large gas wells, free from water, in a genuine syncline, like that at Greensburg, Pennsylvania, or at the bottom of the trough near Irwin, then I shall frankly confess that my judgment has been imposed upon, and that *geological structure* can give no clue to this hidden treasure.

"The reasons why the gas should be stored most abundantly along the arches are so patent that it is unnecessary to state them; the insoluble problem would be how to imprison large quantities of gas in a syncline, except what little might exist in water under pressure.

"If our main proposition be true, viz, that the principal supplies of natural gas have been stored along the *arches* of the rocks, then the question of location must have a very important bearing upon the life of any particular gas field; for whatever may have been the source or origin of the gas, whether as a by-product in the genesis of oil (as much of it certainly is), or from the action of heated saline water on carbonaceous material, thus originating the Murraysville or odorless gas without any oil, as some claim, or in what way soever it is produced, the wells along the arches would have a much longer lease of life.

"Mr. Carll has recently sounded a note of warning through the columns of *The Petroleum Age*, to which those who think the supply inexhaustible would do well to take heed; for certain it is that many wells once large have long since ceased to flow. It is true that many of these have been choked up with salt because the water was not cased off, and the casing having been taken out, a column of water many hundred feet high has imprisoned others, but there is reason for believing that still others have failed because the source of supply was exhausted. On the 'anticlinal theory,' it would be expected that all wells not situated near prominent arches, nor at the upturned ends of vanishing synclines, could not have a long life, since the contents of the reservoir upon which they can draw must necessarily be of limited extent. But not so with those situated along the prominent arches, like that at Canonsburg, Murraysville and Grapeville; for here the quantity in any one sand will be vastly greater than where the rocks are undisturbed, and the disturbance itself will have fractured the rocks and thus given access to many other reservoirs below the one from which the well draws immediately.

"The first Murraysville well has been delivering from fifteen to twenty million feet of gas daily for nearly ten years, and yet, with many other wells in close proximity, its volume has not yet been appreciably diminished. Hence there is good reason for believing that the gas wells situated on the prominent arches may have a much longer life than others not so fortunately placed, and that the immense amount of capital invested in pipe lines to them will receive an adequate return before the gas shall have been exhausted. Nothing but time can determine the life of gas territory situated upon a well developed arch, like the Murraysville or Saltsburg anticlines.

"In Washington county, Pennsylvania, there are three principal geological horizons at which large supplies of gas are found, and, taking the Pittsburg coal as a datum line, these horizons come in as follows, neglecting fractions:

	Feet.
First horizon below Pittsburg coal	900
Second " " " "	1,800
Third " " " "	2,000

"The *first* horizon furnishes a gas very much like the Murraysville gas, and the pressure seldom rises above 300 pounds to the square inch. It is contained in the No. XII conglomerate, since the rock lies about 200 feet above the Subcarboniferous limestone.

"The *second* horizon is identical with the first Venango oil sand, and seems to be the gas horizon *par excellence* of south-western Pennsylvania, since it is also the great producing rock in Beaver, Allegheny, Butler and Westmoreland counties. It is nearly always overlain by a dark, close slate, which has evidently been a factor in enabling the rock to retain the gas. The product of this rock is strongly scented with petroleum in Washington county, but at Murraysville and Grapeville, in Westmoreland, it is nearly odorless, though it is oil scented again near Latrobe.

"This same rock is the gas reservoir at Wellsburg, West Virginia, and has there been identified by Prof. Orton as the Macksburg oil sand, which he in turn identifies with the Berea grit.

"The *third* great gas horizon of Washington county is in the 'stray' or uppermost member of the third Venango oil sand. The famous McGuigan well is in this sand, as also the Donaldson, Willison, McClean, and others in Washington county.

"The total pressure to which the gas from this rock will rise, when shut in, has never been determined, so far as I am aware, but it would probably exceed that from the first Venango, or Murraysville sand, which seldom rises above 650 pounds to the square inch.

"The explanation of gas pressure in any particular rock seems as yet quite obscure, but there is evidently an increase of pressure with increase of depth, though the law of increase (if there be any law) is not uniform. For instance, the wells at Erie which go down 600 to 700 feet, show a maximum of only 40 to 50 pounds. Mr. Westinghouse, of the Philadelphia company, Pittsburg, suggests that the gas pressure in any case may be due to the water, or hydrostatic pressure on the rock, and this is possibly true, since it would account for the greater pressure as the sand gets deeper below the surface,

"Since the above statements with reference to the Washington county gas horizons were written the drill has developed two others, viz., one in the 'Big Sand,' or Manifold farm oil rock, which begins directly under the Mountain or No. XI limestone, and is 250 feet thick. This rock is the

upper member of the Pocono sandstone, and is called in Ohio the 'salt sand.' The horizon in it which furnishes gas is about 1,150 feet below the Pittsburg coal.

"The other gas horizon is the so-called '50-foot rock,' which has proved so prolific in oil at the Smith No. 1. The top of this sand comes about 1,850 feet below the Pittsburg coal, and it is very probably identical with the second Venango oil sand.

*The Criticism of the 'Anticlinal Theory' of Natural Gas.**

Read at the Buffalo Meeting of the American Association for the Advancement of Science, August, 1886, by I. C. White.

"Through inexcusable carelessness (for I cannot be so uncharitable as to charge intentional misrepresentation), the critics of the 'anticlinal theory' of natural gas have invariably misapprehended its claims, and criticised something other than this theory as held and promulgated by the writer.

"My critics have almost invariably written about the theory as though it had been claimed that large gas wells could be found everywhere on every anticlinal roll, and in no other situation whatever. Messrs. Ashburner, Chance and Carll, of the Pennsylvania survey, have all set up for themselves this 'man of straw,' and of course easily demolished him, since no one with whom I have any acquaintance has ever held or published any such theory of natural gas occurrence as they combat. The eminent director of the Pennsylvania geological survey, in his presidential address at Ann Arbor last year, found occasion to refer to the 'exploded anticlinal theory of natural gas' as a splendid piece of 'dead work,' accomplished presumably by the critics already mentioned. It is true that this 'dead work' has effectually buried the anticlinal theory as put forth by these critics, for neither the writer nor any one else ever held any such a theory; but substantially all that I have ever claimed for it has now been so thoroughly established by the 'live work' of the drill, that no geologist, well informed on the subject, will be so rash as to deny the fact.

"The gentlemen who have so freely criticised the 'anticlinal theory' seem to have stopped reading my first paper on the subject, in *Science* of June 26, 1885, when they came to the *limitations* placed on the theory. On no other hypothesis can I understand the grounds of their opposition. Those who have interest enough in the matter to desire to read my papers on the subject will find all of them in the 'Natural gas supplement' of the *American Manufacturer;* and after having done so, they will find that the essence of it all is, that the great supplies of natural gas have accumulated in the rock reservoirs, in regions of disturbance by which the reservoirs in question have been elevated above contiguous areas of the same beds, and in the

*Read by title only at the meeting of the A. A. A. S. in Buffalo, August, 1886; subsequently published in *The Petroleum Age* for November, 1886, (Vol. V. pp. 1464, 1465), from which it is reprinted.

lower levels of which oil and water may be expected; or, in others words, gas has accumulated where anticlinals or monoclinals of considerable (but not too great) extent have raised the rocks into arches and other forms of elevation; and hence, as Professor Orton says, *structure* is the main element in the occurrence of gas and oil in large quantity.

"The theory teaches that it is useless to bore for large gas supplies in a region where there are no considerable or irregular dips, and hence its negative value is of great importance, since in my own experience but a single failure has been made in condemning such regions; and if any further proof was needed, the larger portion of the state of Ohio bears unmistakable testimony to the negative value of the 'anticlinal theory.'

"But probably the strongest testimony in favor of this theory is the almost universal approval of the practical operators. Many of these, I find, have been guiding their own operations on the same principle for many years, and I very much doubt whether a single operator in Pennsylvania could be induced to drill for gas in a well marked syncline.

The great gas fields of Washington and Grapeville, which the writer located on this theory, are sufficient evidence to most people that its claims are not entirely delusive, or the result of coincidence, as my friend Ashburner would have us believe.

"A map which the writer prepared to accompany an article on natural gas in *The Petroleum Age*, has also been a source of trouble to some of my former associates on the Pennsylvania geological survey. One in particular says some very unkind things about it: First, that the scale is too small; second, that the anticlinals are incorrectly placed; and, thirdly, that Mr. Ashburner's 'great' Kinzua-Emporium cross-cut anticlinal is a myth, as likewise all the others, both "great" and small, which appear on the map in question.

"As to the first count in this indictment, I claim exemption from blame, for the original map prepared for this purpose was on a scale of six miles to the inch, instead of ten, as published, and the editors of the *Age* will bear witness that I desired the larger scale, which they declined to publish on account of expense.

"As to the second count, I would say that the mechanical execution of the map was committed to Messrs. Johnson and Grafton, two young engineers and experienced draftsmen, who put the anticlinals on the map from data furnished by the publications of the Pennsylvania geological survey, except, as stated in my accompanying paper, I took the liberty of correcting some of my own work from later and more detailed observations in the southwestern part of the State; and hence, if any serious error occurs in the placing of the anticlinals, it is not the fault of the writer.

"With regard to the last count, the writer pleads that he did not invent the term 'cross-cut anticlinal,' since, in the paper to which reference has been made, he gives due credit to its author and discoverer, Mr. Ashburner. If the black line which has been stereotyped so long on the McKean, Elk and Cameron county maps of the Pennsylvania geological survey, un-

der the name of 'Kinzua-Emporium cross-cut anticlinal,' is really a myth, as Mr. Ashburner himself seems now not unwilling to admit, then the writer shall certainly raise no objections to having the term erased from geological nomenclature, as well as from the maps in question; but the structure that the writer described under this term will not be changed by a change of name.

"As is well known, the main anticlinals of western Pennsylvania extend in a northeast-and-southwest direction, and, as a general rule, the rocks dip down to the southwest along the lines of the anticlinals as well as those of the synclinals; but in some regions, notably at Washington and Grapeville, there is such a swelling up of the anticlinals that the rocks *rise* rapidly to the southwest instead of *dip*, and as some of these bulges on the different anticlinals are in a line with each other, I thought it not improbable that they might be connected in origin at least, and hence, having no other name at hand, adopted the one already coined by Mr. Ashburner for what I supposed represented a similar structure.

"But whatever we may call the structure in question, whether a *swell*, *bulge*, or '*hog-back*,' as one gentleman terms it, the localities where it occurs are those *par excellence* where we may expect large deposits of natural gas; and when large wells have been obtained in the trend of a synclne the structure is found to be complicated by the presence of such a *bulge*, or else a long and rapid rise from the southwest.

"The writer knows that the anticlinal theory, taken in connection with the *limitations*, which are a necessary part of it, is a valuable guide to the geologist in search of natural gas deposits, because he speaks from an experience of more than three years, in which the theory has been put to many practical tests.

The Anticlinal or Structural Theory Not New.

This *structural theory* for the occurrence of petroleum and natural gas, arrived at independently of myself on the suggestion of Mr. Farseman, proved to be not new, but had long before been proposed by other geologists, though none of them, with the exception of Andrews and Minshall, had ever applied its principles in a practical way.

Dr. T. Sterry Hunt, the late eminent Canadian geologist, was probably the first to recognize the principles involved in the *anticlinal theory*, having published a paper on the subject in the *Canadian Naturalist* in

1859, and another in the *American Journal of Science and Arts* for March, 1863.

The late Prof. E. B. Andrews of Marietta, Ohio, also appears to have reached the same conclusions independently of Dr. Hunt, for in an article in the *American Journal of Science*, dated Marietta, May 20th, 1861, descriptive of the "Oil Break" of West Virginia, the influence of anticlinal folds on the occurrence of oil and gas is distinctly announced.

Mr. F. W. Minshall of Marietta, Ohio, advocated the same views as Andrews, concerning the West Virginia "Oil Break" in a series of articles published in the summer of 1881.

Prof. H. Hoefer, the distingushed geologist of Leoben, Austria, also appears to have formulated the same conclusions from a study of the Pennsylvania oil fields in 1876, and published the elements of the anticlinal theory in his book on "The Petroleum Industry of North America," pages 77–80, without any knowledge of the previous publications of Hunt and Andrews, while Newberry, Stevenson, and probably others had advocated the influence of *rock disturbanee* as early as the '70's. Thus it appears that the theory had long ago been recognized and its essential elements published, but the practical oil men had never heard of it in a way to make any impression upon them, and the authors of the theory had made but slight attempts to apply its principles practically in the location and discovery of new oil or gas fields. This is the work which the writer has especially accomplished, and in the doing of it so enforced the lessons of geology upon the minds of the men engaged in the practical work of drilling for oil, that the acceptance of the structural

theory is now almost universal among them, as well as among geologists. In this work the writer has been ably assisted by Dr. Edward Orton, State Geologist of Ohio, whose acute mind and facile pen have done much to popularize and enforce the geological claims of the anticlinal theory. The latest article from Dr. Orton's busy hand is one read before the Geological Society of America at the New York meeting, December 29th, 1898, demonstrating that the very large and recently discovered gas field in Allen county, Kansas, occupies the crest of a great arch in the strata.

The geologists of Indiana have also contributed much to compel belief in the structural theory of oil and gas accumulation.

On the continent of Europe, and in Russia no other theory has any followers whatever, due largely to the work of Hoefer, Sögren, and other geologists. No one can visit Baku, Grozuy, Gallicia, and other oil fields of the old world, and see the great anticlinals which accompany every important deposit of petroleum without concluding that *rock disturbance* is the important factor in such accumulations. It was the numerous oil pools along the crest and flanks of the great "Oil Break" anticlinal that extends from Burning Springs, Wirt county, to Eureka, Pleasants county, West Virginia, which first convinced Prof. Andrews, in 1861, of the agency of *structure* in oil and gas accumulation. Guided by this principle, the writer pointed out and located all of the great oil pools of West Virginia for a Pittsburg syndicate in 1884 and 1885, long before the drill finally demonstrated the correctness of his conclusions. The detailed account of how one of these great pools was subsequently located and developed 35

miles distant from any oil production at the time, has been told by the writer in an article entitled, "The Mannington Oil Field and the History of Its Development," published in the Bulletin of the Geological Society of America, Vol. 3, pages 187–216, April 15th, 1892, to which the reader is referred for the methods pursued in the application of the principles laid down in the "Anticlinal Theory" to the solution of a particular problem. From this paper the following quotation may be made as embodying the essence of the "Anticlinal Theory:"

Essence of the Theory.

"The essential principles involved in the paper and discussions referred to, as embodied in the "anticlinal theory," have been very forcibly and graphically set forth by Professor Edward Orton, whose philosophic mind and skillful hand have grappled with and raveled so many tangled threads of geologic history. Grasping at once the truth of the "anticlinal theory," he applied its principles in a striking and beautiful way to the explanation of the oil and gas deposits of Ohio. Expressed in his words, *relief* or *structure* is the essential element in the accumulation of large quantities of either oil or gas, for if the rocks lie nearly horizontal over a wide area we find, when we bore through them, "A little oil, a little gas, a little water, a little of everything, and not much of anything;" while if the rock reservoirs be tilted considerably, so that the small quantities of oil, gas and water in all sedimentary beds can rearrange themselves within the rocks in the order of their specific gravities, then and then only can commercial quantities of each accumulate, provided the

reservoir and cover are good. The anticlinal waves which traverse the great Appalachian plateau westward from the Alleghanies and practically parallel to these mountains present just such relief as the theory requires in New York, Pennsylvania, southern Ohio and West Virginia oil and gas fields, while the more ancient flexures in northern Ohio and Indiana account for the large accumulations of oil and gas in the Trenton limestone of those States. The Florence (Colorado) and other oil fields in the far western States and territories have this tilted rock structure, and the same relief is plain in the Canadian oil and gas fields, according to Selwyn; while Tschernyschew, Sjögren, and other geologists who have studied the foreign oil fields, report an identical geological structure there.

"This theory, so simple and consonant with well known physical laws, as well as so harmonious with the facts of geology, was heartily welcomed by most of the oil and gas operators, and by nearly all geologists that have given any thought to the matter, as a satisfactory solution of the geologic problem connected with oil and gas accumulation. A few have attempted to relegate the great principle of relief to a subordinate position, but the facts have pointed so conclusively in the other direction that opposition has been silenced at least, whether convinced or otherwise.

"Guided by this theory I located in 1884 the important gas and oil field near Washington, Pennsylvania; also the Grapeville gas field along the great arch of the same name in Westmoreland county; and the Belle Vernon field on the Monongahela river. On the same theory I located and mapped out, for Mr. J. M. Guffey, the celebrated Taylortown oil field of Washing-

ton county months before the drill demonstrated the truth of my conclusions. And right here on this Mannington-Mount Morris belt a derrick was built to bore for oil on one of my locations at Fairview more than five years before the drill finally proved that my location was immediately over one of the richest pools of oil in the country, and before the drill had shown that there was any oil in this portion of West Virginia. These are only a few of the positive fruits of the theory to which we can point; the negative results in condemning immense areas for both oil and gas being even more important in preventing unnecessary expenditure and waste of capital where a search for either gas or oil would have certainly been in vain."

Effect of Mannington Experiment Upon Operators.

The successful outcome of the Mannington experiment converted most operators to a belief in the *structural theory* of oil and gas accumulation, and even the few who may still assert this unbelief in what they call the "anticlinal theory," make use of its principles in all of their petroleum ventures; for there are no prominent operators now who do not observe very closely the *dip* and *strike* of the strata, and many of them employ expert geologists, and engineers to gather data in the field as a guide to successful operations.

Relation of West Virginia Oil and Gas Pools to Geological Structure.

Every gas and oil pool in West Virginia illustrates and demonstrates the truth of the *structural theory.* The Sistersville field occupies the crown of a broad, low anticlinal where the relief is not sufficient to permit the separation of the gas, oil and salt water, and

hence we find them all three commingled until the Big Injun Sand which holds them dips down to a level where only salt water is found. At but one or two limited areas in that great field has gas unaccompanied with oil or salt water been found, and these were (as they should be) where the sand attained its highest elevation.

The great gas district which stretches across Monongalia, Marion, Harrison, and eastern Doddridge counties, lies along the eastern edge of the oil fields, and therefore where the rock is elevated by anticlinal folds, down the slopes of which to the west we find such remarkable oil deposits.

The wonderful gas district of Wetzel and Tyler counties lies along the crest of a prominent arch in the rocks which passing south-westward through Kingtown, crosses the South Fork of Big Fishing Creek through Owl's Head Knob, (the greatest gas region in the country), and continuing on south-westward across Piney Fork, below that village, passes into Tyler county, along the crest of which we find a great gas development extending past Bredin to the "Big Moses" gas field on Indian creek, to which the Philadelphia Company of Pittsburg has laid 75 miles of 16-inch pipe line; while just east of this anticlinal down its southeastern slope lies the Piney Fork, Alva, Hardman, and other great oil deposits.

The string of oil pools along the crest and flanks of the famous "Oil Break" anticlinal from Burning Springs to Eureka, and northward into Ohio, repeat the same story in such a striking way that "he who runs may read," while the sudden termination of the oil pools south-west from this great arch, is a striking

argument for the influence of *structure* in determining the occurrence of oil and gas in paying quantity.

Absence of Prominent Anticlinals Southwest From the Little Kanawha River.

Nearly 200 wells have been drilled in this region southwest from the Little Kanawha, and while "a little oil, gas, and water," have been found in nearly every well, yet as the result of all this drilling we have three or four small gas wells, and two or three oil wells doing five to ten barrels each, daily. It is true the untested region is large, and it may contain several good oil pools, but its lack of prominent anticlinal arches, and other *structural* features associated with the productive territory north from the Little Kanawha, together with the negative results obtained in drilling these 200 test wells, give but little encouragement to the operator, and should lead him to make a careful search for favorable *structural conditions* in this broad area where the rocks are so nearly flat, or have but a gentle and almost uniform dip at best, before risking large sums of money in a fruitless search for oil or gas.

Necessary Conditions for the Existence of Oil or Gas in Underlying Strata.

The surface indications for the presence of oil or gas in any region are, then, the existence of well marked anticlinal waves, or what leads to the same results (viz, the accumulation of oil or gas in pools of merchantable value), the presence of rapid and irregular dips, giving rise to the *terrace* or warped structure of the strata. Of course these must be supplemented by the presence of porous reservoirs at a depth sufficiently great to pre-

vent the escape of oil and gas to the surface in any considerable quantity.

Effect of Oil and Gas Escaping to the Surface.

Where such escape does take place, we get as a result heavy lubricating oils, as in the "shallow sand" district near Petroleum, Ritchie county, in which case the overlying rocks are mostly porous sandstones, and evidently much fractured by the nearness of the great Burning Springs—Eureka uplift.

Effect of Rock Fissures Upon Oil and Gas Deposits.

When this fracturing of the strata has proceeded still further and opened out wide fissures (1–5 feet), as at "Ritchie Mine" on McFarland's Run, Ritchie county, W. Va., extending downward through all the strata to and below the underlying oil sands, thus permitting the escape of large quantities of gas and oil, the subsequent evaporation, and oxidation of the residual products left filling such fissures, have resulted in converting them into an asphaltic substance, resembling coal in appearance, named Grahamite, in the case of the Ritchie Mine deposit. That this was the origin of Grahamite, Albertite, Vintaite, or Gilsonite, is certain, since recent drilling near the Ritchie Mine in West Virginia has revealed a productive oil sand ("Salt Sand") at 1,500 feet below the valley, and what is most significant is the fact that only a little oil is found in the underlying sand until the wells are located 500 to 800 feet distant from the fissure, thus showing that the rock has been drained in the immediate vicinity of the latter.

When Fissures are Small and Through Shale the Oil is Unaffected.

When the fissures are mere joints, and through close-grained beds like shale, the escape of gas and oil to the surface appears to be largely prevented by even a hundred feet or so of such rock material, since at Cairo, Ritchie county, an oil of 35° gravity is produced by the Clark Oil Company from a sand which lies less than 100 feet below the bed of North Hughes River. At Deem's Ferry, on the South Fork of the same stream, an oil of 40° to 42° gravity is found at a depth of only 250 feet, and the oil at the mouth of Island Run has about the same gravity at a depth of 300 feet.

Mountain Regions.

In most mountain regions, the fracturing of the strata has been carried on to such an extent that all the available stores of gas and oil that may once have existed in the beds have passed out of the original reservoirs through their defective covers, escaping into the air, and hence it is useless to drill for oil or gas to any ordinary depth in typical mountain regions.

It is barely possible that under great thickness of close grained beds or shales the gas and petroleum originally contained in rock reservoirs so situated may still be imprisoned. No borings in mountain regions have been sunk to a depth sufficiently great (4,000–5,000 feet) to test the truth of this supposition.

The Significance of Degree Lines.

It has long been a favorite method with many operators for oil or gas to follow some particular degree lines as a basis for further developments after the first

paying oil or gas well is obtained in any region. S. 45° W. or N. 45° E. is a favorite line with many, while 22½°, 30° and 35° as well as other figures have had their adherents. That a considerable measure of success has attended the observance of such lines is a well attested fact and the explanation is not difficult. Such lines are approximately parallel, and sometimes coincident for several miles with the *strike* of the strata, or in other words the direction in which the oil or gas rock lies approximately *level*, which is, of course, in most cases on a line parallel with the *anticlinal axes* or other *structural* features of the region, and the structural theory of oil and gas teaches that in any particular pool the rock which contains the oil or gas, is likely to be saturated with the same as far as it remains porous and occupies the same level. Hence as these lines of *strike*, or no dip, are approximately parallel to the Alleghany mountains (which extend N. E. and S. W. at angles of 30°-45°), any degree line approaching these figures must run some distance along an oil pool of considerable breadth before passing to either side of the same, and thus a degree line is worth something in searching for oil. For example a 45° line from Mt. Morris, Pa., S. W. to Mannington, W. Va., will define a large area of the *Big Injun Sand* oil territory between the two points, and a similar line Northeast from the original *Thomas well* or Flat Run, Marion county, will run for 10 miles or more through that great *Gordon Sand* pool to the front of developments in Monongalia county. In the former case the 45° line would first pass west of the oil belt; then across, and east of it; then back into, and with it to Mannington and beyond, while on the latter or Flat Run belt, the 45° line would be within oil territory at every

point from the Thomas well in Marion to the Gilbert T. Moore well (the furthest to the northeast yet, January, 1899, drilled) in Monongalia. On the Campbell's Run belt, however, which lies 3 to 4 miles west from the Flat Run developments, a 45° line from the original *Stiles well*, to the northeast, would soon pass east of that belt and into the barren area between it and the Flat Run field, while a 35° line would pass near the Sarah Eddy No. 1, the furthest large well to the northeast.

Structural, or Strike Lines Safest to Follow.

The best plan, however, is to disregard the degree lines and follow the *strike* or *level* lines of the surface rocks, such as coal beds, limestones, or presistent sandstones, when neither of the other two classes of strata are available, since the oil sands although many hundreds, or even thousands of feet below the surface, are approximately parallel to the surface rocks, and rise when the latter rise, or dip when they descend; thus when the rocks are level, the oil sands are nearly so. This law holds true for all the area north from the Little Kanawha river, but when we pass southwest from that stream, and start southward the measures thicken so rapidly in that direction that while the surface beds may be *rising*, the oil sands many hundred feet below may lie flat, or even be dipping to the south, and this condition of affairs is possibly one of the causes why no good pools of oil or gas have yet been found southwest from the Little Kanawha region, since the *relief* which even a rapid rise of the surface beds to the southeast would indicate, is offset and overcome by this thickening of the beds below the surface, so that the

regular oil sand formations have little or no relief, being approximately level, and hence according to the "anticlinal theory," may not be expected to hold oil or gas in paying quantity, unless there are areas discovered in that region where these underlying sands have been warped up into folds or more rapid dips than have yet been found.

Rock Pressure in Oil and Gas Wells.

When an oil or gas well is drilled and the casing valve closed so that the product cannot escape into the air, a pressure is developed inside the pipe. This pressure which increases with the depth of the oil or gas reservoir below the surface in about the same proportion as would the pressure in a column of water to the same depths, is known as "*Rock pressure*," and is always greatest when a pool of oil or gas is first opened. When the producing capacity or volume of a well is large, the total pressure which a well will develop when shut in, is attained in a few seconds, or a minute at most, the famous Morgan well of the South Penn Oil Co., six miles southwest from Mannington, having developed a pressure of 800 pounds to the square inch inside a three-inch pipe almost instantly. Wells with such large volume mean very open and porous reservoirs from which the gas or oil can escape with great rapidity. But a well of small volume, if completely shut in, will gradually develop the same "rock pressure," though it may be several hours or even days in attaining it, as the one with large volume, provided, both produce from the same reservoir, and are situated in the same pool.

The volume or value of a gas well is always roughly

estimated from the pressure developed per minute when shut in (called its "minute. pressure") and its total or "rock pressure." The ingenious method of measuring accurately the capacity of any gas well in cubic feet of product, by means of the Pitot tube adapted and modified by Prof. Robison, of the Ohio State University, has not been used by the gas companies operating in West Virginia so far as known to the writer, greatly to their loss and detriment.

Cause of Rock Pressure.

There has been much speculation as to the cause of "rock pressure" in gas and oil wells, and many (including the writer) have believed it was of artesian origin, that is, due to water which has invaded the same rock from its outcrop at the surface. Prof. Edward Orton, the eminent State Geologist of Ohio, who has contributed so much to elucidate the problems connected with petroleum and natural gas, once held this view, and apparently demonstrated its truth for the *Trenton Limestone* gas of Ohio, since in nearly every case the observed pressures agreed with the calculated pressure, assuming it to be of artesian origin and taking the level of Lake Erie as the surface outcrop of the Trenton Limestone. Recently, however, Prof. Orton has made some observations while studying the gas fields of New York that could not be explained upon the artesian theory, since in this case the "rock pressure" was 1500 pounds to the square inch at a depth of many hundred feet less than the theory would require, hence it breaks down as an explanation for all cases of gas and oil pressures, even if it may be the true cause in many fields, like the Trenton Rock of

Ohio, Indiana, etc. In such cases like that of New York we are forced back upon the "*expansion hypothesis*," advocated long ago by Prof. Lesley, as the only theory that will explain the facts, and the same would appear to be the only theory consistent with the facts concerning the high pressures in the deep or Gordon group of oil sands in West Virginia, since nowhere in Monongalia, Marion, Wetzel. Marshall, Tyler, Doddridge or Harrison counties has any water* been found in this group, evidently because they are so deeply buried (2500-3500 feet) by overlying close grained beds that the surface waters have failed to percolate down to them, and hence in these cases there would be no water present in the oil sands to cause the artesian pressure. It is barely possible that the seeming agreement with the artesian pressure theory may be due to the long continued escape of small quantities of gas upward along small fissures and joints through the overlying strata until the pressure of expansion within the rock reservoir has been reduced to what we now find it on opening any new gas field. This appears to be Prof. Orton's explanation of the exceptional pressure found at a comparatively shallow depth in the New York field to which reference has been made. It is also possible that this may account for the apparent agreement between the pressures observed, and the calculated artesian pressures in many new gas fields, since if there should be a constant escape of gas from any pool, the same pressure would decrease continually until

*The only exception to this statement known is a single well of the Delmar Oil Co. on the Shaffer farm, southwest from Mannington, where some fresh water made its appearance in the Gordon sand, but here there is a possibility that it was due to a leak in the outer casings, or a rock fissure communicating with the upper beds which may thus have led the surface waters down to the oil sand after the well was drilled.

the expansive force of the remaining gas just equals the resistance of its passage to the surface, and in the case of small fissures filled with water this pressure would evidently be practically the same as the weight of a column of water extending from the outcrop level of the gas reservoir rock down to its level in the gas pool.

Reservoir Gas and Shale Gas.

Dr. Orton makes a distinction between what he terms *reservoir* gas, and *shale* gas, the former including all *sand* or *limestone* strata, and the latter *shale* beds, which are mostly black. The pressure in *shale* gas is usually low and the volume small, the wells at Erie, Pa., and near Louisville, Ky., being examples of the same. So far as yet developed the West Virginia gas horizons all belong under the first or *reservoir* type, unless indeed we should include under the *shale* series, that found in the coal beds and in the deep boring near Huntington. Several examples are known in West Virginia as well as Pennsylvania, where valuable flows of gas have been obtained from coal beds. One of these was struck at Hundred, Wetzel county, W. Va., in 1886, by Messrs. Gibson and Giles, in the Pittsburg coal, at 700 feet in depth. Enough gas was found therein according to Mr. Gibson, with which to finish drilling the well through the Gordon sand, and it still furnishes a portion of the supply for the village.

Volume and Maximum Rock Pressure in Gas Wells.

The great gas wells of West Virginia from the deep or *Gordon sand group* have never been tested for rock pressures when the pools in which they are situated were first opened, and hence we do not know exactly

how great this pressure may be in the regions where these sands lie deepest.

The Thomas Cunningham No. 1, of the South Penn Oil Company in Wetzel county, is one of the very large wells in the Gordon group, and on July 1st, 1898, after it had been completed nearly a year, and had blown into the air several months before it was possible to shut it in, the rock pressure was still 1,200 pounds to the square inch.

The W. J. McCoy well in Greene district, Wetzel county, is also another very large well drilled by the same company. Mr. Wm. S. Edwards of Mannington, Superintendent of the South Penn Oil Co., reports that the McCoy gas well showed a pressure of 1,075 pounds in one minute in 5 3-16-inch casing, which was the limit of the test. This well has a depth of about 2,800 feet, and the Cunningham the same, as both produce from the "*Stray*" immediately above what is called the "*Gordon sand*" in Wetzel.

The Abe Shriver well No. 1 in Battelle district, Monongalia county, drilled by the South Penn Oil Co., gave a *rock pressure* of 1,200 pounds (the limit of the guage) on a one minute test in 3-inch tubing. The Pittsburg coal was struck at 780 feet in this well, and the gas in the Gordon, or Flat Run sand at 3,007 feet.

Mr. John Worthington, of the South Penn Co., believes that the largest gas well both in volume and rock pressure ever discovered in West Virginia or any other state, is the E. C. Morgan well No. 1, drilled by the South Penn Co., six miles southwest from Mannington, Marion county. The top of the gas sand in the Morgan well was struck at 3,052 feet, the *Pittsburg coal* having been passed at 890 feet, thus giving the

same interval (2,162 feet) below the latter stratum as the *Gordon "Stray"* or *Campbell's Run oil sand* occupies on Campbell's Run, Marion county, Miracle Run, Highland, and other regions in Monongalia county, and hence this gas is possibly from the same horizon as the great wells in Wetzel county to the west, though the interval from the Pittsburg coal to the gas sand is 100 feet less in Wetzel than in the Morgan well. At about three feet in the sand at the Morgan well, or 3,055 feet from the surface, the gas was struck, and so great was its pressure, that the drilling tools weighing several thousand pounds, were lifted from the bottom of the well, and blown above the top of the derrick, through 6⅛-inch casing, more than 100 feet into the air, according to Mr. Worthington. The well defied all the usual methods of procedure in shutting in large gas wells, and only after three months of uninterrupted work, was it finally conquered by the ingenuity of Messrs. Edwards and Worthington, and the men whom they directed. The 3-inch tubing could not be inserted in the 6⅛-inch casing in the customary manner, but required the pull of "block and tackle" to force it into the well. Then when the proper depth (2270 feet) had been reached, where it was decided to set the rubber packer, it would not "take hold," and on withdrawing the tubing no *rubber* was visible, the fine sand and pebbles having been blown by the gas against it with such force as to destroy the rubber entirely and blow its material out as dust. This occurred several times, until Messrs. Edwards and Worthington decided to wrap the "packer" with iron wire before inserting the same, and finally proved successful and the well was shut in. This is the well which gave a pressure of 800 pounds (the limit of the guage) almost instantly, or within two

or three seconds, according to Mr. Edwards. The well was completed on the 19th of August, 1893, and has been supplying the towns of Fairmont and Grafton, 25 miles distant for the last four years. It still showed a rock pressure at the well of 765 pounds, January 1, 1898, and of 550 pounds January 1, 1899. Its production through the open casing when first struck, must have been enormous, probably between forty and fifty million cubic feet daily.

The greatest pressure recorded from this same sand was made in the Nineveh region of Greene county, Penna., where a gas well on the Michael Funk farm was shut in by Mr. John Worthington, and although of comparatively small volume, the *rock pressure* finally surpassed the limits of the guage (1500 pounds to the square inch), and did not stop until it blew up the 2-inch pipe with which it was shut in, probably developing a pressure of 1600 to 1700 pounds to the square inch, since this class of pipe is supposed to be tested to 2,000 pounds before it leaves the factory.

It is quite probable that the total *rock pressure* in these deep sands (*Campbell's Run, Flat Run, 4th, 5th and 6th*) of West Virginia would exceed 1500 pounds to the square inch in the deepest portions of the field, if shut in and packed down to the top of each stratum in question.

A curious fact was discovered at the Alonzo Edwards well No. 1, near Wadestown, Monongalia county, West Va. This well was drilled by the Battelle Oil Company, and considerable gas was developed in the *Gantz Sand* horizon at 2770 feet, as well as in the "*Fifty-Foot*" *Sand* at 2840 feet, and a still larger flow was found in the *5th* or *McDonald Sand* at 3115 feet,

the hole being completed at 3300 feet. The *Gantz* and "*Fifty-Foot*" sands constituted one solid, coarse, pebbly rock, and in order to save all of the gas flows, the well was packed in the upper portion of this pebbly stratum. From the great depth of the well, it was expected that the *rock pressure* would rise until it exceeded 1,500 pounds to the square inch, but when shut in the guage which began to register rapidly at first, very soon slowed up, and finally stopped at only 650 pounds. As the pressure did not rise sufficiently rapid to correspond to the apparent volume of the gas when the gate valve was open, it was concluded that a large portion of the gas was being forced into the porous *Gantz* and "*Fifty-Foot*" beds, and *stored* therein, the 650 pounds representing the pressure necessary to store in the pores of that rock all the surplus gas produced from the three horizons at that pressure. This *storing* process could not of course go on indefinitely, since the new reservoir would require additional pressure to force the gas further and further back into the rock, and the conclusion was reached that in time the *rock pressure* of the well would show a large increase, and that the gas being thus stored up in natural reservoirs would be available for future consumption. This conclusion has recently been verified. The well was shut in early in 1898, and not opened again (as there was no consumption for it) until January, 1899, when it was opened up and turned into a two-inch gas line for use in drilling oil wells. The pressure, though not measured, proved so great that the two-inch pipe was blown up in several places, and it was found necessary to place a "reducing" arrangement upon the well.

Mr. Glen T. Braden, General Manager of the South Penn Oil Co., reports that he had the same experience

with a well in Marion county, W. Va., similarly packed several hundred feet above the gas producing horizon, and that after the well had been shut in for 30 days, its pressure rose more rapidly and went to a higher point when opened and again closed in, thus demonstrating that the gas was being forced into porous beds and stored there in such a manner as to be available for future use. These facts should give a hint to the gas companies concerning a cheap method of *storing* gas wells not needed in the lines, viz., to connect the same with partially exhausted wells, and thus prevent too high pressures in the pipe lines, and at the same time preserve for useful work this surplus gas which would otherwise be wasted into the air from safety valves, etc.

The following letter from Mr. N. Johnson, Superintendent of the Carnegie Natural Gas Co., Pittsburg, Pa., gives the results of his measurements of high rock pressures in gas wells:

Rock Pressures Measured by the Carnegie Natural Gas Co.

DR. I. C. WHITE,
Morgantown, W. Va.,

DEAR SIR:—Your inquiry of the 31st ultimo received. The highest rock pressure that I know, of my own knowledge, is 1140 pounds, and three of the largest wells that we now own are as follows:

Sixth sand, 3,400 feet deep, 6-inch hole and packed with 2,400 feet of 4-inch tubing; first minute, 400 pounds; rock pressure, 1,100 pounds.

Fifth sand, 3,200 feet deep, 6-inch hole, packed with 2,200 feet of 4-inch tubing; first minute, 350 pounds; rock pressure, 1,100 pounds.

Fifty-Foot sand, 2,440 feet deep, 5 3-16-inch casing; first minute, 450 pounds; rock pressure, 660 pounds.

Our Mr. Hoffman states that we drilled a well at Grapeville which had an open pressure of 37 pounds, in 6-inch casing, and when closed in, went to 580 pounds, as quick as the gate could be closed, which was also its rock pressure. He also tested the Snee well on the Wright farm in Forward township, Allegheny county, which we purchased; casing, 6 5-8-inch, depth

of hole, 1,800 feet, Gantz sand; first minute, 628 pounds; rock pressure, 780 pounds.

Yours very truly,

N. JOHNSTON,
Superintendent.

These statements of Mr. Johnston reveal the same conditions concerning the packing of the deep *Sixth* and *Fifth* sand wells of Greene county, Pa., as just related in reference to the Edwards well of the Battelle Oil Co., viz., the wells' being packed several hundred feet above the gas producing sands, permits the accumulating pressures from the latter to force the gas into other porous rocks above, and thus the total rock pressures observed are not nearly so great as they probably would be had the wells been packed down close to the producing sands, and the disappearance, or storing of gas in these higher porous beds thus effectually prevented.

The *rock pressures* in the *Big Injun Sand* are less than those in the *Gordon group*, since the top of the *Big Injun* lies 800-900 feet above the top of the *Gordon*.

In the Mt. Morris region of Pennsylvania, and the adjoining district of Monongalia county, West Virginia, the pressure was about 550 pounds to the square inch soon after the field was opened in 1886, while at Blacksville, 8 miles west, where the same sand lies about 100 feet lower, the *rock pressure* in the *Big Injun* was 600 pounds when the first well was drilled. At Mannington the *Big Injun Sand* gave a total of 550 pounds at the Blackshere gas well, the first one opened to that sand, while the Snoderly gas well in the *Pottsville conglomerate* ("Salt Sand,") 400 feet higher up in the geological scale, stopped at 380 pounds. At Harrisville, Ritchie county, the *rock pressure* in the Big

Injun sand was 680 pounds in the first well drilled by the Keystone Co., as reported by its president, Dr. D. H. Courtney, while still higher pressures are reported for this sand from the western or Cairo region of Ritchie county.

Mr. W. K. Jacobs, Superintendent of the Cairo Oil Co., Cairo, W. Va., informs me that when he first came to the Cairo region, 3 years ago ('96), the *rock pressure* in the *Salt Sand* gas wells was about 600 pounds to the square inch, and 900 pounds in the "*Big Injun*" sand below, thus greatly exceeding the highest pressures observed for the same strata in the northern portion of the State.

Oil and Gas Strata of West Virginia.

In drilling for oil and gas in West Virginia the operators have penetrated the entire column of rocks from near the top of the *Permo-Carboniferous* beds down to the *Corniferous Limestone*, near the base of the Devonian, though not all in one region of the State.

The following generalized section of this column of rocks may be introduced here for comparison with the names of the oil sands, and as showing the geological horizons of the different beds between the highest exposed strata in the state, and the bottom of the deepest borings, (Corniferous Limestone). The section is supposed to start from the top of one of the highest knobs along the dividing ridge separating the streams which pass eastward through Monongalia county to the Monongahela river, from those which pass westward through Wetzel and Marshall counties to the Ohio river:

Sandstone, shale and concealed.....100′ to 100′

Limestone, *Windy Gap*	5	"	105
Shales and concealed with coaly blossom.	55	"	160
Sandstone, massive, *Gilmore*, "*Efaw*," "*Pethtle*," etc	30	"	190
Concealed with *red shales*, sandstone and limestone	275	"	465
Coal, Nineveh, John Taylor, exposed over both Glover's Gap and Board Tree tunnels, B. & O. R. R	1	"	466
Shales and sandstone	25	"	491
Limestone, Nineveh, (exposed at each end of Board Tree tunnel; B. & O. R. R.	10	"	501
Concealed, *red shales* and sandy beds	40	"	541
Sandstone, massive, *Fish creek*	25	"	566
Coal, Dunkard	1	"	567
Shales, limestone, and concealed, with a thin coal bed	20	"	587
Sandstone, massive	20	"	607
Coal, Jollytown	2	"	609
Limestone	5	"	614
Concealed, sandstone, and shale, some *red*	135	"	749
Massive sandstone, *Marietta*, and shales, sometimes containing a slaty coal and limestone	100	"	849
Coal, Washington, seen in hills around Mannington, Pine Grove, New Martinsville, Sistersville, West Union, Cairo, Ritchie Mines, Spencer, etc	3′ to 5	"	853
Shales and sandstone, with often a thin limestone and coal bed	80	"	933
Coal, Waynesburg, "A"	0′ to 4	"	935
Shales and limestone	10′ to 20	"	950
Sandstone, Waynesburg, "*Bluff*," "*Hurry Up*,"			

etc., of the drillers	60	" 1010
Shales, base of *Permo-Carboniferous*	10	" 1020

Monongahela River Coal Series, No. XV.

Waynesburg coal, mined at Cassville, Monongalia Co., Fairview, and near Downs in Marion Co., and from Long Run to near West Union in Doddridge Co	0′ to 4	" 1022
Shales	10	" 1032
Sandstone, Browntown, cuts of B. & O. R. R., just east of Mannington; makes cliffs along Ten Mile, at Brown's Mills, Harrison Co	30	" 1062
Shales and limestones	60	" 1122
Sandstone, Uniontown, probably the "shallow oil sand" operated on the Carroll farm, by the Clark Oil Co., at Cairo, Ritchie Co., W. Va	20	" 1142
Coal, Uniontown	0′ to 2	" 1143
Shales, limestone, and limy shales, very green about midway	120	" 1263
Sewickley sandstone, sometimes massive, but often flaggy, with much limestone interstratified	30	" 1293
Sewickley coal, "*Mapletown*" of oil drillers, mined on Scott's and Robinson Runs, Monongalia Co., and along the Monongahela river from Worthington in Marion Co., to Gray's in Greene Co., Pa., being 4 to 6 feet thick, but thinning away to the southwest, as well as to the northeast; reported by		

drillers westward, across Monongalia, Marion, Wetzel and Marshall to the Ohio river, probably same as *Meigs creek coal* of Ohio.....	4′ to	6	" 1298
Shales, limestone and sandstone.....		56	" 1354
Coal, Redstone, mined on Scott's and Robinson runs, Monongalia Co.; also east of Jarvisville and other points in Harrison Co.; also on Peck's Run, Upshur county.; and Burnersville, Barbour Co.; sometimes (once near Jarvisville, and once on Pedlar's Run, Monongalia Co.,) mistaken by drillers for the Pittsburg coal below; thickness.....	0′ to	4	" 1356
Shales and limestone, or sandstone.....		35	" 1391
Coal, Pittsburg, the great "key" rock of the Monongalia, Marion, Harrison, Doddridge, Wetzel and Marshall Co. oil and gas fields; mined around Fairmont, Clarksburg, Weston, Buckhannon, Troy, Glenville, Wheeling, Moundsville shaft, Hartford, Spillman, Raymond City, etc., etc.; absent along the "Oil Break" anticlinal between Burning Springs and Eureka, and from a large area in Tyler, Doddridge, Ritchie, Gilmer, Pleasants, Wood, Wirt, Jackson, Roane, Clay, Calhoun, and other counties in the southwestern part of the State; thickness including "roof" coals.....		10	" 1401

Elk River Series, or Barren Measures, No. XIV.

Shales, thin limestones, sandstones and sandy beds	210	"	1611
Sandstone, Morgantown, "shallow oil" sand at mouth of Island Run, Ritchie Co., and at Deem's Ferry, below the California House, same county; also produced oil on Dunkard creek, Greene Co., Pa., sometimes called *Little Dunkard sand;* may be same as *1st Cow Run* sand, in the old Cow Run development of Ohio; often pebbly, quarried half-way up the hill-sides at Morgantown	25	"	1636
Elk Lick coal, often absent	0' to 4	"	1638
Shales, limestones and red beds	50	"	1688
Green Crinoidal Limestone	0' to 2	"	1689
Coal, Crinoidal, mined at Burning Springs, Wirt Co.	0' to 2	"	1690
Red shales, bad "*cave*" and "*Big red*" of the oil drillers	50	"	1740
Blue and red shales and sandy limy beds, also "caving" at times	170	"	1910
Mahoning Sandstone, Dunkard Oil Sand, often called the "*Cow Run*" *Sand* by the oil well drillers, but it is possible the *1st Cow Run Sand* or "140 foot" rock is identical with the Morgantown sandstone above; quarried at Charleston along Elk river for building stone; crops out in great cliffs between Petroleum and Volcano, B. & O. R. R., also near California House,			

on South Fork of Hughes river, and at the Eureka Pumping station and other points along the Monogahela between Morgantown and Little Falls; sometimes double with a shale intervening; an important oil horizon at Burning Springs, and in Wood, Pleasants, and Tyler counties; also near Moundsville in Marshall Co.; thickness.....50′ to 100 " 1985

Lower, or Allegheny River Coal Series, No. XIII.

Upper Freeport Coal, mined at Austen and Tunnelton on B. & O. R. R....0′ to 8 " 1989
Limestone and Shales..... 20 " 2009
Freeport Sandstones, one of the "gas sands" of the drillers; produced some oil at Fairview, Marion Co., W. Va., in P. W. Yost well No. 1, and is probably the *2nd "Cow Run" sand* of the old Cow Run development of Ohio.....130 " 2139
Shales, with *Upper, Middle* and *Lower Kittanning* coal beds..... 50 " 2189
Fire clays, shales, sandy beds, and sometimes a limestone, (*Ferriferous,*) near center..... 60 " 2249

Pottsville Conglomerate No. XII.

New River Coal Series.

The "*Salt Sand*" of the drillers in West Va., consisting of three to four members, separated by shales, and some-

times containing thin coal beds; the *New River* and *Pocahontas coals* belong in these rocks; important oil and gas horizons at Burning Springs, Cairo, and other regions of the State, the "Maxton" sand being the lowest member of the group, and probably identical with the "Salt Sand" at Cairo; one of the upper members of this group also called the "gas sand" by drillers; thickness.....200 " 2449

Mauch Chunk Red Shales, No. XI.

Lower Carboniferous.

A series of *red shales*, green sandstones, and impure limy beds; no oil or gas known in these rocks; a dark slate near base caves badly in long splinters, hence its name of "pencil cave"; thinning away entirely westward in Ritchie, Tyler, Pleasants, Wood, Wirt, and all the counties along or near the Ohio river, thus letting the *Pottsville beds* above rest immediately upon the *Mountain* or "*Big Lime*" below; thickness.....0' to 300 " 2599

Mountain or Greenbrier Limestone, the "*Big Lime*" of the drillers; another "key" rock for the petroleum seekers, and almost always present; thickens southward to 1400 feet in Greenbrier, Summers, etc., on the south-western boundary of the State;

thickness in the oil regions,...80′ to 100 " 2689

Pocono Sandstone, No. X.

Top member of this series, the "*Big Injun*" *oil sand* of the drillers, a hard and often fine-grained gray sandstone, with usually two, and occasionally, three or four open, coarse, and porous, sometimes pebbly layers, filled with oil, gas, or salt water, called "*pay*" *streaks* by the drillers; in Monongalia, Marion and eastern Wetzel counties often unbroken by slate from top to bottom, and usually 140 to 150 feet thick, with a *gas* "*pay*" at 15 to 20 feet in the rock; the *1st oil* "*pay*" at 60 to 75 feet; the *2nd* or main one at 80 to 90 feet; and often a *3rd*, at 100 to 110 feet below the top of the sand. In Tyler, Pleasants, Ritchie, and other counties, the uppermost 20 to 30 feet of the "Big Injun" of Monongalia, Marion and Wetzel, usually separated from the main body of the rock by from 5 to 15 feet of dark slate, is then called the "*Keener Sand*," and becomes an important oil and gas zone in the counties mentioned, though in Monongalia, Marion and eastern Wetzel nothing but *gas* has ever been found at this horizon, the main body of the "Big Injun" oil of these counties

occurring at 75 to 90 feet below the top of the sand; entire thickness of "*Big Injun*" including "*Keener*" *sand*.....140′ to 150 " 2834
Dark sandy shales.....20′ to 40 " 2864
"*Squaw*" *sand* of drillers.....20′ to 30 " 2889
Shales and sandy beds..... 380 " 3269

Catskill, No. IX, Top of Devonian Beds.

Black and *red shale beds* of the uppermost Devonian..... 20 " 3289
Gantz and "Fifty-Foot" Sands; in Monongalia and Marion often a coarse, pebbly solid body of rock without a break for 90 feet or more (the "*Second Sand*" or "*Hundred Foot*" of Butler Co., Pa.,) having a *gas "pay"* at 10 to 20 feet from top (*Gantz sand*), and another 30 to 50 feet lower ("Fifty-Foot"); has produced some oil south-west from Mannington, Marion Co., and recently a small quantity in the Cynthia Kent Well No. 1 of the South Penn Oil Co., in Battelle district, near Cross Roads, Monongalia county, at 1945 feet below the Pittsburg coal bed. In the Fink or Vadis field of Lewis county, several small wells have been discovered in this sand along with salt water as in Butler Co., Pa. The formation as a whole appears to be identical with the *Macksburg oil sand* of

Ohio which Dr. Orton, the State Geologist, has identified with the great quarry rock at Berea near Cleveland where it is 75 feet thick and known as the *Berea Grit*, so that this name, whether the identification be correct or not, has been fastened by the driller upon the deep producing sand in Wood, Pleasants, and Ritchie counties, as well as upon the sand in the Turkey Foot oil field of Hancock and the *gas sand* of Brooke Co.; thickness in Marion, Monongalia, Wetzel, Doddridge, Harrison and Lewis counties.....50′ to 100 " 3364

Red and Blue shales, sandy beds, and a well defined *sand* near center known to drillers under the name "*Thirty-Foot*," which has produced gas, but no oil yet so far as known in W. Va. The *red* and blue shales "cave" in the deep drilling of Monongalia, Marion and eastern Wetzel, and must be cased off with a "liner" before drilling into the oil or gas bearing sands below; thickness.....180′ to 200 " 3554

Campbell's Run Oil Sand, of Marion and Monongalia, called the *Gordon "Stray,"* in the Flat Run field to the east, where it is gas bearing, as also in the deep sand borings of Piney Fork, Mills and other pools in Wetzel Co.; a splendid oil producer of flowing wells in western Marion and

Monongalia, notably on the 'Moore Heirs', Johnson, Toothman, Haught, and other farms; thickness..... 20 " 3574

Dark slate and sandy shales.....10′ to 30 " 3594

"*Gordon Sand*," of the drillers, *Flat Run Sand*, the deep producing sand at Flat Run, Mannington, and Whetstone, in Marion to the south-west, and at the Highland, Harvey, Haught and Walker, regions to the north-east in Monongalia, and at the Eddy and Wise farms near Cross Roads on the Campbell's run oil belt in Monongalia. The largest (3010 barrels in 24 hours) oil wells in the state, and the most productive have been found in this sand, which may be the *Gordon* of Washington Co., or the *4th sand* just below, if we call the "*Stray*" or *Campbell's Run Sand*, the *Gordon;* these questions remain in abeyance; thickness.....20′ to 30 " 3619

Dark shales, or sandy beds.....30′ to 50 " 3659

McDonald, or *Fifth Oil Sand*, of the Washington and Allegheny county group, of Pennsylvania; the oil rock near Jarvisville, Harrison Co., and the *gas rock* on the Woodford farm below Weston, and showing a little oil on the Summers farm, Lewis county; produces *gas* on Edwards farm near Wadestown, Monongalia Co., and on Brown farm, Dunkard creek, near Worley P. O.; thickness.....2′ to 40 " 3680

Elizabeth, Sixth Sand, produces gas on Core, Wright, McCord, and other farms near Mooresville, Monongalia Co., small oil wells, 5 to 10 barrels, on the Blair, Shriver and other farms near Worley P. O. on Dunkard creek along the West Virginia and Pennsylvania line; basal member of Catskill beds; thickness.....5′ to 15 " 3840

Chemung and Hamilton Beds, No. VIII.

Gray and dark shales with an occasional shell, or thin, hard, fine-grained sandy bed, penetrated 2000 feet in the Boggs Run, Wheeling, deep well, and in the Forest Oil Co's deep well on the Wm. Bedell farm, near West Elizabeth, Pennsylvania, they were penetrated 3260 feet below the *Sixth* or *Elizabeth Sand*, and 5680 feet below the *Pittsburg coal*, without reaching the *Corniferous Limestone;* but in the Central City deep well, on Four Pole near Huntington, at the south-west corner of the State, the *Corniferous Limestone* was struck at 2760 feet or only 3100 feet below the Pittsburg coal bed, and but 2130 feet below the top of the "*Mountain*" *limestone*, while the Bedell well near Elizabeth passed 4505 feet below the same *limestone* horizon, stopping in the *Hamilton* shales, probably not more than

100 feet above the *Corniferous beds*, thus giving a thinning away between Elizabeth and Huntington of 2680 feet as measured from the *Pittsburg coal*, or 2475 feet if measured from the top of the *Mountain Limestone*. The bottom of the lowest sand struck in the Central City well, lies 849 feet above the *Corniferous Limestone*, while if we estimate this limestone at 100 feet below the bottom of the Elizabeth well, it would there lie 3360 feet below the *Sixth* or deepest oil sand, which gives a difference of 2,511 feet between the Elizabeth and Huntington wells, due to *thinning* of the *Chemung* and *Hamilton beds*, or practically the same as that obtained (2680′ and 2475′) when we take the *Pittsburg coal* or *Mountain limestone* as datum planes, so that the westward thinning is thus shown to be confined practically to the Chemung-Hamilton series. A mean of the two measurements of these formations would give (849′+ 3360′) ÷ 2 = 2105′ for the thickness of these beds at the longitude of say, Parkersburg, but adding the full Elizabeth thickness for the Monongalia and Marion county region gives the following total from the top of the *Permo-Carboniferous* to the *Corniferous limestone*.....3360′ + 3840′ = 7200′

Summary of the Section.

The preceeding tabular statement of the West Virginia rock series may be summarized as follows for convenience of reference as to thickness, etc.:

Dunkard Creek Series, Permo-Carboniferous or Permian, No. XVI, of Rogers.

Contains much red shale, some massive sandstones, thin limestones, and a few thin coal beds, rocks, slightly gypsiferous, Permian flora, fresh water deposits, no oil nor gas horizons yet developed; thickness..... 1020 ft.

Monongahela River Coal Series, No. XV. Permo-Carboniferous flora, fresh water fauna.

Contains much limestone, but little red shale; some massive sandstones, one of which, the *Uniontown* (?) is the highest known *oil sand* (*"Carroll"*) yet developed in the Appalachian field; five coal beds, the most important of which, the celebrated *Pittsburg seam* at the base of the series is used as a *"key" rock* for casing, etc., by the drillers in several counties of the state; thickness of entire series..... 381 ft.

Elk River Series, or Barren Measures, No. XIV.

Holds much red shale and "caving" material in upper two-thirds; *Permo-Carboniferous fauna and flora*, thin limestones, three or four thin coal beds, several important sandstones, two of which, the Morgantown and

Mahoning, are important oil sands, the latter known as the *Dunkard* or *Cow Run Sand*, and these two horizons with the *Uniontown Sandstone* above constituting what is known as the "*shallow sand*" *territory*; lower half of this series certainly of marine or litoral origin; thickness ..... 584 ft.

Allegheny River Coal Series, No. XIII.

Same as *Great Kanawha coal series*; no red beds, but dark shales, and gray sandstones, interstratified with *five important coal beds*, and two or three thin limestones; *marine fossils, typical coal measure flora*, one oil and gas horizon; the *2nd Cow Run*, and one of the "*Gas Sands*" of the drillers; thickness of series..... ..... 264 ft.

Pottsville Conglomerate, New River or Pocahontas Coal Series, No. XII.

Massive pebbly sandstones, usually bearing salt water, and therefore termed "*Salt Sands*" by the drillers, the several members separated by dark shales which hold thin coals at the north, but important fuel beds in the southern portion of the State, where the formation is greatly thickened; the different members, especially the lower ones, *Cairo, Maxton*, etc., becoming important depositories of *gas and oil* in Ritchie, Tyler, Pleasants, Wood, Wirt and Roane; thickness in southern region (Fayette-McDowell) 1500 feet; in northern region (Marion-Monongalia)..... 200 ft.

Lower or Sub-Carboniferous.

Mauch Chunk Red Shale, No. XI.

A series of soft red "caving" shales, interstratified with green sandstones, and impure limy beds, the "Pencil cave" being a dark slaty shale near base; the whole series thinning away westward to nothing; no productive oil or gas horizons known; thickness in Monongalia and Marion..... 150 ft.

Mountain or Greenbrier Limestone, No. XI.

"*Big Lime*" of the drillers, a hard gray limestone; thickness..... 90 ft.

Pocono Sandstone, No. X.

Big Injun Oil Sand, including "*Keener sand*" horizon at top, one of the most important oil and gas horizons in the State; thickness of entire "*Big Injun*," including "*Squaw sand*" ..... 200 ft.

Shales and sandy beds to base of *Pocono series*, or bottom of Lower Carboniferous; *Smith's Ferry oil sand*, and possibly "*Berea*" included therein; thickness..... 380 ft.

Catskill Beds, No. IX.

Venango Oil Sand Group.

Massive, pebbly sandstones, interstratified with *red* and dark shales, and including the *Gantz* (*Berea Grit*?), "*Fifty-Foot*," "*Thirty-Foot*," "*Stray*" (*Campbell's Run*), *Gordon* (*Flat Run 4th*), *McDonald* or *Fifth* and the *Sixth* or *Elizabeth sand*, all impor-

tant oil or gas horizons; thickness in Monongalia and Marion..... 571 ft.

Ghemung and Hamilton No. VIII.

Gray and dark shaly sandy beds as described above, and containing no oil or gas horizons of importance yet discovered in West Virginia, but the *Warren* and *Bradford Oil Sands* of Pennsylvania probably belong in the upper portion of these measures; thickness in Monongalia and Marion, as estimated from the West Elizabeth deep boring.....3360 ft.

7200 ft.

For comparison with the oil sands and several measures of the Pennsylvania section we shall here introduce the detailed record of the S. B. Phillips well No. 1, in the McDonald field of that State, kept for me with great care and minuteness by Mr. T. J. Vandergrift, President of the Woodland Oil Gompany. A sample of the rock material was taken, washed, dried and preserved, at every sand pumping from the *Pittsburg coal* to the bottom of the well through the McDonald, or Fifth Oil Sand, with frequent *steel line* measurements at every important change in the stratification. The samples (570 in all) were inclosed in small sacks duly labeled with the consecutive number and depth as the work progressed, and a careful "log" of the same kept by the drillers who were induced by Mr. Vandergrift to take especial pride and care in having the work complete and accurate. Through the kindness of this intelligent operator and public spirited citizen, the West Virginia Survey is now in possession of

these samples, and the original record which is believed to be more complete than any other oil well record ever taken, is here published for the first time. On account of its importance as a standard for comparison with the West Virginia series of strata, it is given in full, and in the exact language of the drillers who kept the same. The record reads as follows:

Record of S. B. Phillips Well No. 1, McDonald, Pa., Oil Field, Drilled by Wally and Seybert, Contractors, for the Woodland Oil Co., T. J. Vandergrift, President.

Commenced to spud September 3rd, 1894.

Sack No.		Interval.		Feet.	In.
1	Top of coal, Pittsburg, Sept. 5th, Steel line	86	to	86	
	Through coal	4	"	90	
2	Fire clay	5	"	95	
3	Gray sand	5	"	100	
4	Limestone and black slate	5	"	105	
5	Limestone	2	"	107	
6	Limestone	2	"	109	
7	Limestone, Sept. 6th, Steel line	1	"	110	
8	Limestone	2	"	112	
9	Limestone	3	"	115	
10	Limestone	4	"	119	
11	Lime shells and slate	5	"	124	
12	Lime shells and white slate	6	"	130	
13	Gray sand and slate, Sept. 7, Steel line	9	"	139	
14	Gray sand	5	"	144	
15	Gray sand	5	"	149	
16	Gray sand	5	"	154	
17	Black slate	5	"	159	
18	Gray sand and slate	5	"	164	
19	Gray sand and slate	3	"	167	
20	Gray sand	6	"	173	
21	Gray sand	6	"	179	
22	Gray sand	5	"	184	
23	Gray sand	5	"	189	
24	Gray sand	5	"	194	
25	Gray sand	5	"	199	
26	Gray sand, Sept. 8th, Steel line	1	"	200	

27	White slate	5	"	205
28	White slate	4	"	209
29	White slate	5	"	214
30	White slate and red rock	5	"	219
31	Red rock	5	"	224
32	Red rock	5	"	229
33	Red rock	5	"	234
34	Red rock	5	"	239
35	Red rock	5	"	244
36	Red rock	6	"	250
37	Red rock	5	"	255
38	Red rock	3	"	258
39	White slate, Sept. 10th, Steel line	2	"	260
40	White slate	5	"	265
41	White slate and coal	5	"	270
42	White slate and coal	5	"	275
43	White slate	5	"	280
44	White slate	10	"	290
45	White slate	5	"	295
46	White slate	5	"	300
47	White slate	5	"	305
48	Black slate	5	"	310
49	Black slate	5	"	315
50	Black slate	0	"	315
51	Black slate	5	"	320
52	Black slate	5	"	325
53	Black slate	5	"	330
54	Black slate	5	"	335
55	Black slate	10	"	345
56	Black slate, Steel line, Sept. 11th	6	"	351
57	Black slate	5	"	356
58	Black slate	5	"	361
59	Black slate	5	"	366
60	Black slate	5	"	371
61	Black and white slate	6	"	377
62	White slate	5	"	382
63	White slate	5	"	387
64	Gray sand, soft	5	"	392
65	Gray sand, soft	5	"	397
66	Gray sand, soft	5	"	402
67	Gray sand, soft	5	"	407
68	Gray sand, soft	6	"	413
69	Gray sand, soft	6	"	419
70	Gray sand, soft	6	"	425
71	Gray sand, soft	6	"	431
72	Gray sand, soft	7	"	438
73	Gray sand and black slate, Sept. 13th	21	"	459

74	Black slate	5	"	464
75	Red slate	6	"	470
76	Red and white slate	5	"	475
77	White slate	6	"	481
78	White slate	5	"	486
79	White slate	6	"	492
80	White slate	6	"	498
81	White slate	5	"	503
82	White slate	5	"	508
83	White slate and sand	5	"	513
84	Gray sand	6	"	519
85	Gray sand and slate	5	"	524
86	Gray sand and slate	5	"	529
87	Black slate	6	"	535
88	Black slate	6	"	541
89	Gray sand	7	"	548
90	Gray sand	7	"	555
91	Gray sand	8	"	563
92	Black slate	7	"	570
93	Black slate	7	"	577
94	Black slate	7	"	584
95	Black slate	7	"	591
96	Black slate and coal	7	"	598
97	White slate	8	"	606
98	White slate, Sept. 14th. Steel line	8	"	614
99	White slate	7	"	621
100	White slate	6	"	627
101	White slate	6	"	633
102	White slate	6	"	639
103	White slate	6	"	645
104	White slate	7	"	652
105	White slate	6	"	658
106	White and red slate	6	"	664
107	White slate	6	"	670
108	White slate	7	"	677
109	White slate	6	"	683
110	White slate	6	"	689
111	White slate and shells	6	"	695
112	White slate and sand	8	"	703
113	Black slate	7	"	710
114	Black slate	8	"	718
115	Black slate	7	"	725
116	White slate	7	"	732
117	White slate	8	"	740
118	White slate	8	"	748
119	Black slate	8	"	756
120	Black slate	8	"	764

121	*Cannel* coal	7	"	771
122	White slate and limestone shells	8	"	779
123	White slate and lime	7	"	786
124	Black slate, Sept. 15th. Steel line	8	"	794
125	Black slate	8	"	802
126	Black slate	8	"	810
127	Black slate	8	"	818
128	Black slate	7	"	825
129	Black slate	6	"	831
130	Black slate	8	"	839
131	Coal and black slate. Steel line	7	"	846
132	Coal and fire clay; water. Steel line	6	"	852
133	Black slate.	5	"	857
134	Fire clay	5	"	862
135	Black slate	7	"	869
136	Black sandy bed, traces of coal	3	"	872
137	Black slate	6	"	878
138	Black slate and shells	6	"	884
139	Coal and slate	5	"	889
140	Black slate and shells, Sept. 17th. Steel line	1	"	890
141	Black slate and shells, hard	5	"	895
142	Black slate and shells, hard	2	"	897
143	Black slate and shells, hard	3	"	900
144	Shells, very hard.	2	"	902
145	Shells, very hard	1	"	903
146	Black sand and shells, Sept. 18th, filled with water. Steel line	4	"	907
147	Black slate	5	"	912
148	Black slate and shells	2	"	914
149	Black slate and shells	5	"	919
150	Black slate and shells	2	"	921
151	Black sand and shells	2	"	923
152	Black sand, hard	4	"	927
153	" " "	1	"	928
154	" " " Sept. 19th. Steel line.	2	"	930
155	" "	3	"	933
156	" "	4	"	937
157	" " soft	5	"	942
158	" " "	3	"	945
159	" " "	3	"	948
160	Black sand, soft	4	"	952
161	Black slate and coal, Sept. 20th. Steel line	5	"	957 6″
162	Gray slate and fire clay	2	"	959
163	Black sand and shells	1	"	960
164	Black slate	5	"	965
165	Black shells	2	"	967 6″
166	Black slate, some coal	3	"	970 6

LIBRARY OF THE UNIVERSITY OF CALIFORNIA

167	Black slate and shells		3	"	973
168	" " " "		3	"	976
169	Gray sand		4	"	980
170	" " Sept. 21st. Steel line		6	"	986
171	Black Slate		5	"	991
172	Black slate and shells		5	"	996
173	Gray sand and shells		5	"	1001
174	Gray sand		3	"	1004
175	" "		4	"	1008
176	" " Sept. 22d. Steel line		6	"	1014
177	" "		5	"	1019
178	" "		4	"	1023
179	" "		2	"	1025
180	Black sand		3	"	1028
181	" "		2	"	1030
182	Black slate and shells		5	"	1035
183	" " " "		5	"	1040
184	Gray sand		5	"	1045
185	" "		2	"	1047
186	Black slate, Sept. 26th. Steel line		1	"	1048
187	Black sand		3	"	1051
188	Gray sand		3	"	1054
189	" "		4	"	1058
190	White sand		3	"	1061
191	" "		1	"	1062
192	Gray sand		3	"	1065
193	" "		2	"	1067
194	White sand		3	"	1070
195	" "		3	"	1073
196	" "		2	"	1075
197	" "		1	"	1076
198	" " Sept. 28th. Steel line		1	"	1077
199	" "		1	"	1078
200	" " hard		1	"	1079
201	" " "		2	"	1081
202	" " "		2	"	1083
203	" " sample rusty from steel bit which was lost in hole		1	"	1084
204	" "		1	"	1085
205	" " hard		1	"	1086
206	" " "		1	"	1087
207	" " " Sept. 29th. Steel line		0 6″	"	1087 6″
208	" " "		1 6	"	1089
209	" " "		1	"	1090
210	" " "		2	"	1092
211	" " "		1	"	1093
212	" " "		1	"	1094

213	White sand, hard	2	" 1096	
214	" " " Oct. 1st. Steel line	2	" 1098	
215	" " "	1	" 1099	
216	" " "	2	" 1101	
217	" " "	1	" 1102	
218	" " hard	1	" 1103	
219	" " "	1	" 1104	
220	" " " Oct. 2nd. Steel line	0 6″	" 1104 6″	
221	" " "	0 6	" 1105	
222	" " "	1	" 1106	
223	" " "	1	" 1107	
224	" " "	1	" 1108	
225	" " " Salt Sand	1	" 1109	
226	" " " " "	1	" 1110	
227	" " " " "	1	" 1111	
228	" " " " "	2	" 1113	
229	" " " " "	1	" 1114	
230	Black sand, Oct. 3rd. Steel line	3	" 1117	
231	" "	3	" 1120	
232	Black slate, Oct. 3rd. Steel line	4 6″	" 1124 6″	
233	" " through salt sand	5 6	" 1130	
234	" "	6	" 1136	
235	" "	6	" 1142	
236	" "	6	" 1148	
237	" sand, soft	6	" 1154	
238	" " "	7	" 1161	
239	Black sand and slate	7	" 1168	
240	" " " "	6	" 1174	
241	" slate, Oct. 8th. Steel line	6	" 1180	
242	" "	5	" 1185	
243	" "	5	" 1190	
244	" " and shells	3	" 1193	
245	" "	7	" 1200	
246	" "	5	" 1205	
247	" "	5	" 1210	
248	" "	5	" 1215	
249	" "	6	" 1221	
250	" " and sand	5	" 1226	
251	" " " "	6	" 1232	
252	Top of Big Injun, gray sand. Steel line	5 6″	" 1237 6″	
253	Gray sand, soft	4 6″	" 1242	
254	" " "	3	" 1245	
255	" " "	7	" 1252	
256	" " "	7	" 1259	
257	" " "	6	" 1265	
258	" " October 9th. Steel line	7	" 1272	
259	" "	6	" 1278	

260	Gray sand, soft	6	"	1284	
261	" " "	6	"	1290	
262	" " "	6	"	1296	
263	" " "	6	"	1302	
264	" " "	6	"	1308	
265	" " "	6	"	1314	
266	" " "	6	"	1320	
267	" " "	5	6″ "	1325	6″
268	" " "	4	6 "	1330	
269	" " "	5	"	1335	
270	" " " October 10th. Steel line	4	"	1339	
271	" " "	6	"	1345	
272	" " "	4	"	1349	
273	" " "	2	"	1351	
274	" " "	3	"	1354	
275	" " hard	2	"	1356	
276	" " "	4	"	1360	
277	" " "	4	6″ "	1364	6″
278	White sand, hard	0	6 "	1365	
279	" " "	2	"	1367	
280	" " "	4	"	1371	
281	" " "	4	"	1375	
282	" " soft	5	"	1380	
283	" " "	5	"	1385	
284	" " " October 11th. Steel line	5	"	1390	
285	" " "	7	"	1397	
286	Gray sand, hard	3	"	1400	
287	" " "	3	"	1403	
288	" " "	4	"	1407	
289	" " "	3	"	1410	
290	" " soft	5	"	1415	
291	White sand, soft	4	6″ "	1419	6″
292	" " "	4	"	1423	6
293	" " "	4	6″ "	1428	
294	Black sand and black slate, soft	6	"	1434	
295	Black slate and sand	6	"	1440	
296	Black slate, October 12th. Steel line	5	"	1445	
297	Gray sand	6	"	1451	
298	" "	5	"	1456	
299	" "	6	"	1462	
300	Gray sand and slate, through Big Injun. Steel line	7	"	1469	
301	Black slate	7	"	1476	
302	Black slate	7	"	1483	
303	Black slate	6	"	1489	
304	White slate	6	"	1495	
305	" "	6	"	1501	
306	" "	6	"	1507	

307	White slate	6	" 1513
308	Gray sand	4	" 1517
309	Gray sand and slate	5 6″	" 1522 6″
310	Black slate	5 6	" 1528
311	Black slate	2	" 1530
312	Black slate and hard shell, Oct. 13th. Steel line	2	" 1532
313	White slate and shell	4	" 1536
314	" " " "	6	" 1542
315	" " " "	6	" 1548
316	" " " " sandy	5	" 1553
317	White slate and sand	4	" 1557
318	Gray sand, top of Squaw, Oct. 13th. Steel line	1	" 1558
319	Gray sand, hard	1	" 1559
320	" " "	1 6″	" 1560 6″
321	" " "	1	" 1561 6
322	" " "	0 6″	" 1562
323	" " "	1	" 1563
324	" " "	2	" 1565
325	" " " Oct. 15th. Steel line	2	" 1567
326	" " "	1 6″	" 1568 6″
327	" " "	1 6	" 1570
328	" " "	1	" 1571
329	Black slate, break in Squaw	4	" 1575
330	" " " " "	5	" 1580
331	Gray Sand	1	" 1581
332	" "	3	" 1584
333	" "	2	" 1586
334	" "	4	" 1594
335	" "	4	" 1594
336	" "	5	" 1599
337	Black slate, through Squaw, Oct. 16th. Steel line	6	" 1605
338	" "	5	" 1610
339	" "	6	" 1616
340	" "	6	" 1622
341	" "	6	" 1628
342	" " and shells	5	" 1633
343	" " " "	6	" 1639
344	" " October 17th. Steel line	6	" 1645
345	" "	6	" 1651
346	" "	6	" 1657
347	" "	6	" 1663
348	White slate and shells.	6	" 1669
349	" " " "	5	" 1674
350	" " October 18th. Steel line	5	" 1679
351	" " and shells.	6	" 1685
352	" " " "	6	" 1691
353	" " " "	6	" 1697

354	White slate and shells	6	" 1703
355	" " " "	6	" 1709
356	" " " "	6	" 1715
357	Black slate	6	" 1721
358	" "	6	" 1727
359	" "	6	" 1733
360	" "	6	" 1739
361	" " October 19th. Steel line	6	" 1745
362	" "	6	" 1751
363	" "	6	" 1757
364	" "	6	" 1763
365	" "	7	" 1770
366	" "	6	" 1776
367	" " and shells	6	" 1782
368	" " " " hard	2	" 1784
369	" " and sand	6	" 1790
370	" "	6	" 1796
371	" "	4	" 1800
372	Gray sand	1	" 1801
373	White sand and slate	5	" 1806
374	" " hard	1	" 1807
375	" " October 20th. Steel line	2	" 1809
376	" "	2	" 1811
377	" " hard	1	" 1812
378	" " "	1	" 1813
379	" " "	2	" 1815
380	Blue sand	4	" 1819
381	" " soft	5	" 1824
382	Sand and shells	5	" 1829
383	Gray slate	1	" 1830
384	" "	5	" 1835
385	" "	5	" 1840
386	" "	5	" 1845
387	Hard sand or shell	1	" 1846
388	" " October 22nd. Steel line	1	" 1847
389	Slate and shells	3	" 1850
390	Black slate	5	" 1855
391	Slate and shells	3	" 1858
392	" " "	2	" 1860
393	" " "	5	" 1865
394	Black slate	6	" 1871
395	" "	7	" 1878
396	Black slate	7	" 1885
397	" " and shells	6	" 1891
398	" "	7	" 1898
399	" " October 23rd. Steel line	8	" 1906
400	Red rock	7	" 1913

401	Red rock	7		"	1920
402	Black slate and shells	6		"	1926
403	" " " "	6		"	1932
404	Top of " 100-Foot " Sand, Oct. 23rd. Steel line	2		"	1934
405	Gray sand	3		"	1937
406	" "	3		"	1940
407	Dark sand	3		"	1943
408	" " hard	2		"	1945
409	White sand, hard	3		"	1948
410	Fine sand, blue, hard	4		"	1952
411	October 24th. Steel line	2		"	1954
412	Gray sand, hard	1		"	1955
413	" " "	2		"	1957
414	" " "	1		"	1958
415	" " "	1		"	1959
416	Slate and sand, break in " 100-Foot "	5		"	1964
417	" " " " " " "	6		"	1970
418	White sand, hard	1		"	1971
419	" " "	3		"	1974
420	" " " October 25th. Steel line	1		"	1975
421	Gray sand, hard	1		"	1976
422	" " "	1		"	1977
423	" "	6		"	1983
424	October 25th. Steel line. Gas in " 100-Foot " Sand and filled up with water	6		"	1989
425	Gray sand	1		"	1990
426	" "	2		"	1992
427	" "	1		"	1993
428	" " October 26th. Steel line	0	6″	"	1993 6″
429	" " hard	0	6	"	1994
430	White sand, hard	1		"	1995
431	" " "	1		"	1996
432	" " "	1		"	1997
433	Gray " "	1		"	1998
434	" " "	1		"	1999
435	" " " October 27th. Steel line	1		"	2000
436	" " very hard	0	6″	"	2000 6″
437	" "	0	6	"	2001
438	" "	0	6	"	2001 6
439	" "	0	6	"	2002
440	" "	0	6	"	2002 6
441	" " October 29th. Steel line	0	6	"	2003
442	" "	0	6	"	2003 6
443	" "	0	6	"	2004
444	" "	0	6	"	2004 6
445	" "	0	6	"	2005
446	" "	0	6	"	2005 6

447	Gray sand	October 30th. Steel line	0	6″	" 2006
448	" "		0	6	" 2006 6″
449	" "		0	6	" 2007
450	" "		0	6	" 2007 6
451	" "		0	6	" 2008
452	" "		0	6	" 2008 6
453	" "		0	6	" 2009
454	Gray sand		0	6	" 2009 6
455	" "		0	6	" 2010
456	Dark sand		1		" 2011
457	" "		2		" 2013
458	" "		1		" 2014
459	" "		2		" 2016
460	Black slate, through "100-Foot" Sand, Nov. 1st. Steel line. Cased 4⅞-inch, Nov. 23		7		" 2023
461	Black slate		6		" 2029
462	" "		5		" 2034
463	" "	and shells	5		" 2039
464	" "	" "	6		" 2045
465	" "	" "	4		" 2049
466	" "	" "	1		" 2050
467	" "	" "	5		" 2055
468	" "	" "	5		" 2060
469	" "		5		" 2065
470	" "		5		" 2070
471	" "		5		" 2075
472	" "		5		" 2080
473	" "		5		" 2085
474	" "		5		" 2090
475	" "	and shells, Nov. 24th. Steel line	1		" 2091
476	" "	" "	4		" 2095
477	Gray sand, top of "30-Foot"		1		" 2096
478	" "		3		" 2099
479	" "	hard	1		" 2100
480	" "	"	1	6	" 2101 6
481	" "	"	1	6	" 2103
482	" "	"	0	6	" 2103 6
483	" "	"	0	6	" 2104
484	" "	"	0	6	" 2104 6
485	" "	"	1	6	" 2106
486	" "	"	1		" 2107
487	" "	soft	2		" 2109
488	" "	show of oil. Steel line	2		" 2111
489	" "		1		" 2112
490	" "		3		" 2115
491	" "	and slate, bottom of "30-Foot." Steel line	5		" 2120

492	Black slate	5	to 2125	
493	" "	5	" 2130	
494	" "	6	" 2136	
495	" "	6	" 2142	
496	" "	5	" 2147	
497	Top of Gordon Sand, Nov. 25th. Steel line	3	" 2150	
498	Gray sand, soft	5	" 2155	
499	Black sand	4	" 2159	
500	Gray sand	4	" 2163	
501	" "	2	" 2165	
502	" " a little gas	2	" 2167	
503	" "	1	" 2168	
504	" " November 26th. Steel line	1	" 2169	
505	" "	2	" 2171	
506	" "	1	" 2172	
507	" "	1	" 2173	
508	" "	2	" 2175	
509	" "	2	" 2177	
510	" "	4	" 2181	
511	" "	1	" 2182	
512	" " November 27th. Steel line	1 6″	" 2183	6″
513	" "	0 6	" 2184	
514	" "	2	" 2186	
515	White sand, more gas, Nov. 27th. Steel line	2	" 2188	
516	" " more gas	5	" 2193	
517	" "	1	" 2194	
518	" "	2	" 2196	
519	" "	3	" 2199	
520	" "	3	" 2202	
521	" "	2	" 2204	
522	" "	2	" 2206	
523	" " hard	1	" 2207	
524	" "	1	" 2208	
525	Sand and slate, through Gordon, Dec. 1st. Steel line	2	" 2210	
526	Black slate	8	" 2218	
527	" " and shell	3	" 2221	
528	Gray sand, "Stray above the 4th Sand"	2	" 2223	
529	" " " " " " "	4	" 2227	
530	Black slate	5	" 2232	
531	" "	6	" 2238	
532	" "	5	" 2243	
533	" "	5	" 2248	
534	" "	5	" 2253	
535	Gray sand top of "4th Sand," Dec. 3rd. Steel line	2	" 2255	
536	" " hard	1	" 2256	
537	" " "	1	" 2257	
538	" " "	1	" 2258	

539	" " "	1	to 2259
540	" " "	3	" 2262
541	" " "	1	" 2263
542	" " "	1	" 2264
543	White sand "	1	" 2265
544	" " "	1	" 2266
545	" " "	1	" 2267
546	Gray "	2	" 2269
547	" " and slate	1	" 2270
548	Black sand, bottom of "4th Sand," Dec. 4th. Steel line	3	" 2273
549	" " and slate	2	" 2275
550	" slate	5	" 2280
551	" "	5	" 2285
552	" "	5	" 2290
553	" "	5	" 2295
554	" "	5	" 2300
555	" "	5	" 2305
556	" "	5	" 2310
557	" slaty sand, hard	1	" 2311
558	Top of "5th Sand," Dec. 5th. Steel line	4	" 2315
559	Gray sand	2	" 2317
560	" "	2	" 2319
561	Black sand	2	" 2321
562	Gray sand, hard	1	" 2322
563	" " and slate	3	" 2325
564	" "	4	" 2329
565	" " hard	1	" 2330
566	" " " "pay streak," Dec. 6th. Steel line	1	" 2331
567	" " some more oil	1	" 2332
568	" "	3	" 2335
569	Black slate	2	" 2337
570	" " and completed Dec. 6th, 1894. Steel line	5	" 2342

Summary

This detailed record may be summarized as follows:

Monongahela River Series.

Only partially represented, the Pittsburg bed having but 86 feet of measures above at the locality of the well; interval represented, including the

Pittsburg coal at bottom..... 90′ to 90′

Elk River Series, Barren Measures, No. XIV.

Including the *Elk Lick coal* at 265 feet, *Mahoning coal* at 591 feet, and the top of the *Mahoning, Dunkard,* or *Cow Run sand* at 541 feet. The whole series extending to about 703 feet; thickness .....613′ " 703′

Allegheny River Coal Series, No. XIII.

Upper Freeport coal, absent or represented by black slate, at 703 feet; *Lower Freeport coal* at 764 feet, the *Upper Kittanning coal* at 839 feet, the *Middle Kittanning bed* at 869 feet, the *Lower Kittanniug coal,*at 884 feet, the *Clarion coal* at 952 feet, the *Lower Clarion* at 967′ 6″, and the base of the series or top of *No. XII, Pottsville Conglomerate,* at 976 feet, thus making the thickness of the *Allegheng River Series,*...273′ " 976′

Pottsville Conglomerate, No. XII.

" *Salt Sand* " of the drillers, samples 169-244 inclusive; thickness .....217 " 1193′

Mauch Chunk Red Shale, No. XI.

Absent as *Red Shale,* and only feebly represented by the black slate of Nos. 245-251 inclusive; thickness.....39′ to 1232′

Pocono Sandstone, No. X, "Big Injun" Oil Sand. Total Thickness of Group 597 Feet.

Nos. 252to 300 inclusive, make up the *"Big Injun"* Sand which is here quite hard and has no representative of the *Mountain Limestone* or *"Big Lime"* of the drillers at its top, as no trace of lime could be found with acid in that portion of the interval; thickness of *"Big Injun" Sand*,	237′	" 1469′
Interval, mostly shales, and hard sandy beds, Nos. 301 to 317 inclusive; thickness	88′	" 1557′
"Squaw" Sand, Nos. 318 to 336, inclusive, a hard gray sandstone, with 9 feet of black slate near the middle; thickness	42′	" 1559′
Interval of black and gray shales with some sandy beds, Nos. 337 to 371 inclusive; thickness	201′	" 1800
Sand, mostly white and hard, Nos. 372 to 382, inclusive, probably the basal member of the *Pocono Series, No. X;* thickness	29′	" 1829′

Catskill Beds No. IX, Containing Venango Oil Sand Group.

Interval, gray and black shales, with 14 feet of *red beds* near the base, Nos. 383 to 403, inclusive; thickness	103′	" 1932′
Gantz Sand, uppermost member of the		

Venango Oil Sand Group, hard, grayish white sand, Nos. 404 to 415, inclusive; thickness..... 27′ " 1959′

Slate "break," 416–417, inclusive; thickness..... 11′ " 1970′

"Fifty-Foot" Sand, hard, white and gray sand, gas and water at 13 feet below its top; no slaty layers; Nos. 418–459, inclusive; thickness..... 46′ " 2016′

Interval, mostly dark shales, some sandy, Nos. 460-476, inclusive; thickness... 79′ " 2095′

"Thirty-Foot" Sand, gray, hard sand, with show of oil 14 feet below top, Nos. 477-491, inclusive; thickness..... 25′ " 2120′

Black Slate, Nos. 392-496, inclusive; thickness..... 27′ " 2147′

Gordon Sand, little gas at 18 feet below top, in upper, *gray* portion, and more at 37′ to 44′, in lower *white* sand division of the rock, Nos. 497-525′ inclusive; thickness..... 63′ " 2210′

Interval, mostly black slate, with a thin "stray" sand, Nos. 526-534, inclusive; thickness..... 33′ " 2253′

Fourth Sand, gray and white, hard, Nos. 535-548, inclusive; thickness..... 20′ " 2273′

Interval, mostly black slate, Nos. 549-557, inclusive; thickness..... 38′ " 2311′

Fifth, or McDonald Sand, "pay" streak, or *oil*, 19 feet below top, a gray sand,

Nos. 558–568, inclusive, (making Venango Group 403 feet); thickness.. 24′ to 2335′

Interval, black slate to bottom of well, Nos. 569-570, inclusive; thickness.. 7′ " 2342′

In passing southward from the McDonald field of Pennsylvania into the northern part of West Virginia, the intervals between the *Pittsburg coal*, and the top of the *"Big Injun" Oil Sand*, thicken, nearly 200 feet by the coming in of the *Mauch Chunk red beds*, and the underlying *Mountain Limestone*, but from the top of the *"Big Injun" Sand* down through the *Venango Oil Sand Group*, there is but little change except in the character of the several strata, as may be seen by the record of the

Alonzo Edwards Well No. 1.

Drilled by the Battelle Oil Company on the farm of Alonzo Edwards, near Wadestown, Monongalia county, three miles south of the Pennsylvania-West Virginia line. Authority, D. H. Courtney, Vice President. Completed, February, 1898.

Elevation of derrick floor above tide, about 1,085 feet.

	Feet.
Unrecorded	840 to 840
Pittsburg coal	10 " 850
Unrecorded	1,302 " 2,152
"Big Injun" Sand	204 " 2,356
(Some gas at 2,167, and a little salt water at 2,242 feet. Cased through sand with 6⅝ casing).	
Unrecorded	384 " 2,740
Red shale	10 " 2,750
Gantz sand small gas flow at 2,770, no break between *Gantz* and *"Fifty-Foot" Sand*, but both pebbly, grayish white sands, with fair gas flow in *"Fifty-Foot"* at 2,840, the two sands together having a thickness of	95 " 2,845
Slate	10 " 2,855
Red shale	10 " 2,865
Hard sandy beds	80 " 2,945
Hard shells and unrecorded	70 " 3,015

Pebbly sand, (*Campbell's Run*)	5	to	3,020
Red sandy beds	15	"	3,035
Blue slate	11	"	3,046
White sand, "*Fourth*," *Flat Run* "*Gordon*" *sand*	9	"	3,055
Hard slate and sandy beds	47	"	3,102
White, hard, pebbly sand, fair gas flow at 3,115, "*Fifth Sand*," *McDonald*	40	"	3,142
Dark gray, sandy shales, to bottom of hole	158	"	3,300

Total thickness of Venango Oil Sand Group (from top of Gantz to bottom of McDonald Sand) 392 feet, or only 12 feet less than in the type section from the McDonald field.

Another record of a very deep well with careful measurements at important horizons is that of Noah Price No. 1, near Highland Church, on the line between Marion and Monongalia counties. It is lacking in details but is here introduced to show the general agreement with the structure in the Edwards well, so far as it goes:

Noah Price well No. 1.

On the Noah Price farm, near Highland Church, Monongalia-Marion county line, West Virginia. Owners, Hartman Oil Company. All measurements with steel line. Authority, Mr. Logan, Contractor.

	Feet.		
Conductor	12	to	12
Unrecorded	588	"	600
Red rock (10-inch casing to 650)	50	"	650
Unrecorded	180	"	830
Waynesburg Sandstone ("*Bluff*" *Sand*)	"		...
Unrecorded	433	"	1,263
Pittsburg coal	"		.....
Unrecorded (8¼ casing to 1756)	522	"	1,785
Dunkard Sand, Mahoning	45	"	1,830
Unrecorded	313	"	2,143
"*Salt Sand*"	"		.....
Unrecorded	345	"	2,488
"Pencil cave"	"		.....
Unrecorded (*Mountain limestone*)	67	"	2,565
"*Big Injun*" *Sand*, (6¼ inch casing at 2575)	88	"	2,653

(Show of oil, gas and salt water)			
"*Big Injun*" *Sand*, (5-inch casing 2728)	75	to	2,728
Unrecorded	437	"	3,165
(Gas, small flow, in top of *Gantz Sand* here)		"	.....
Unrecorded—with red and dark shales and sand	266	"	3,431
"*Stray*" *Sand*, very hard, (*Campbell's Run*)	19	"	3,450
Soft slate and dark shells	18	"	3,468
Gordon Sand, (*Flat Run*,) first "pay" at 3473′, and second "pay" (300 bbl. well) 10 feet lower	25	"	3,493

The following record of the Samuel Eakin well No. 1, three miles south from Wadestown, drilled by the South Penn Oil Company, although not complete, in details, yet gives measurements between important strata, and serves for comparison :

Samuel Eakin Well No. 1.

On the farm of Samuel Eakin, in Battelle District, Monongalia county. Authority, South Penn Oil Company.

			Feet
Conductor	16	to	16
Unrecorded (10-inch casing 190′)	490	"	506
"*Bluff*" *Sand* (*Waynesburg*)	54	"	560
Waynesburg coal	4	"	564
Unrecorded	263	"	827
Mapletown coal. (*Sewickley*)	7	"	834
Unrecorded	93	"	927
Pittsburg coal	10	"	937
Unrecorded	497	"	1,434
Dunkard Sand (cased 8¼ inch at 1458′)	10	"	1,444
Unrecorded	67	"	1,520
Sand	28	"	1,548
Unrecorded	32	"	1,580
"*Gas Sand*" (*Freeport*)	80	"	1,660
Unrecorded	80	"	1,740
Sand	12	"	1,752
Unrecorded	76	"	1,828
"*Salt sand*"	98	"	1,926
Unrecorded	198	"	2,124
"Pencil cave"	6	"	2,130
"Big Lime"	90	"	2,220
Unrecorded (water at 2302 in "Big Injun")	624	"	2,844
Gantz and *Fifty-Foot Sands* (show of gas at 2864 ; oil at 2870 ; gas, strong, at 2880)	116	"	2,960

Unrecorded	56 to	3,016
"*Thirty-Foot Sand*"	16 "	3,032
Unrecorded	10 "	3,042
Sand and shells	39 "	3,081
Campbell's Run Sand (oil at 3092; slate 3104 to 3105)	31 "	3,112
Bottom of well	"	3,112

The record of a well drilled on the Ewing heirs farm adjoining the Eakin, was kept for me with much detail through the *Venango Group* by Mr. Joseph W. Craig, President of the Chartiers Oil Company—the owner of the well. It exhibits the following succession down to the *Campbell's Run oil sand:*

Ewing Heirs' Well No. 1.

On the farm of the heirs of John H. Ewing in Battelle District, Monongalia county. Authority, Chartiers Oil Company.
Water well 185 ft.

	Feet.
Conductor 14.	
Mapletown coal (*Sewickley*) at	835
Pittsburg coal at	924
(10-inch casing at 934 ft.)	
Top of first *Red* at	1,060
Top of second *Red* at	1,150
Dunkard Sand at	1,350
(8¼-inch casing at 1538 ft.)	
Gas sand (water at 1745) at	1 700
Top *Salt Sand* at	1,820
Bottom *Salt Sand* (water at 1890) at	1,934
(6⅝-inch casing at 1995.)	
Top "*Big Lime*" at	2,130
Top of "*Big Injun*" at	2,200
(Gas and a little water at 2280 ft.; 5 3-16 inch casing 2360.)	
Top of *Gantz Sand* (steel line measurement) at	2,830
(Little gas at 2848; big gas at 2870.)	
Bottom of "*Fifty-Foot*" *Sand*	2,945
Slate, pink	2 to 2,947
Hard shell, pink	10 " 2,957
Soft shell, *red*	2 " 2,959
Hard sand, *red*	5 " 2,964
Soft slate, *red*	5 " 2,969
"*Thirty-Foot*" *Sand* — sand, hard, gray	30 " 2,999
"*Thirty-Foot*" *Sand* — sand, hard, white	2 " 3,001
"*Thirty-Foot*" *Sand* — sand, hard, blue	25 " 3,026

Soft slate, black	5 to	3,031
Hard sand, pink	36 "	3,067
Soft sand, pink	4 "	3,071
Slate, black	2 "	3,073
"Liner" (steel measurement)		3,072
Shells	5 "	3,077
Red shale	13 "	3,090
Top *Campbell's Run Sand* (oil at 3098 ft.)		

The record of a well near Worley P. O., Monongalia county, within sight of the Pennsylvania line, on Dunkard Creek, gives the succession through the *McDonald* or *Fifth Oil Sand* of the *Venango Group*, in which a large gas well was obtained, and as the well starts at the horizon of the *Washington coal*, it gives valuable data. The record was kindly furnished by the South Penn Oil Company, owners of the well, and is as follows:

Brown Heirs' Well No. 1.

On the farm of the Heirs of A. W. Brown, Dunkard Creek, Clay District, Monongalia county. Authority, South Penn Oil Company.

		Feet.
Conductor	12 to	12
"*Bluff sand*" (*Waynesburg*)	...	115
Mount Morris coal (*Waynesburg*)	...	180
Mapletown coal, (Sewickley)	...	440
Pittsburg coal	... "	520
Slate and shells (10-inch casing 551′ 6″)	145 "	665
Sand, gray	120 "	785
Red and blue cave	65 "	850
Slate and shells	45 "	895
Coal	2 "	897
Sand, dark	13 "	910
Slate and shells	85 "	995
Sand, white, "*Little Dunkard*" (*Mahoning*)	30 "	1,025
Slate	65 "	1,090
Coal (*Upper Freeport*)	2 "	1,092
Slate and shells	53 "	1,145
Sand, white, "*Big Dunkard*" (*2nd Cow Run*)	15 "	1'160
Slate and shells	30 "	1,190
Coal, (*Upper Kittanning*)	3 "	1,193
Slate and shells	72 "	1,265

Sand, gray	40 to	1,305
Slate and shells	35 "	1,340
Sand, gray	20 "	1,360
Coal, (*Clarion* or *Brookville*)	2 "	1,362
Slate	8 "	1,370
Salt Sand	180 "	1,550

(Water at 1,390 ft.; 8¼-inch casing at 1,414 ft.; 6⅝-inch casing at 1,601 ft.)

Slate and shells	20 "	1,570
Red rock	105 "	1,675
Slate and shells	40 "	1,715
Limestone	45 "	1,760
Unrecorded	80 "	1,840
"*Big Injun*" *Sand* (water and oil at 1,888 ft.)	125 "	1,965
Slate	5 "	1,970
Sand, gray	20 "	1,990
Slate	55 "	2,045
Sand, gray	35 "	2,080
Slate	70 "	2,150
Sand	100 "	2,250
Slate and shells	30 "	2,280
Sand, dark	12 "	2,292
Slate and shells	88 "	2,380
Sand, white	30 "	2,410
Slate and shells	15 "	2,425
Sand, white (*Gantz*)	27 "	2,452
Slate and shells	14 "	2,468
"*Fifty-Foot*" *Sand*: Sand, gray	14 "	2,482
"*Fifty-Foot*" *Sand*: Slate	5 "	2,487
"*Fifty-Foot*" *Sand*: Sand, white	23 "	2,510
Red rock	5 "	2,515
Slate and shells	7 "	2'522
Sand, gray	15 "	2,537
Slate and shells	20 "	2,557
Sand, white	5 "	2,562
Red rock	5 "	2,567
Sand, brown	11 "	2,578
Red rock	47 "	2,625
Sand, red	12 "	2,637
Slate and shells	103 "	2,740
Sand, gray (*Fourth*, or *Flat Run Sand*)	13 "	2,753
Slate and shells	42 "	2,795
Sand, Fifth, McDonald, (strong gas at 2,816 ft.)	35 "	2,830
Total depth		2,830

Total thickness of Venango Oil Sand Group, 405

feet, almost exactly the same as in the Phillips well (403 ft.) of the McDonald field given above.

Just east of the Brown well a few hundred feet, and on the southern bank of Dunkard creek, a well was drilled on the land of Mr. Lee R. Shriver by the South Penn Oil Company, through the *Elizabeth* or *Sixth Sand* which is there petroliferous. This important record is here given through the kindness of the aforesaid Company, as follows:

Record of Lee R. Shriver Well No. 1.

Dunkard Creek, Monongalia County, W. Va.

Drilled 1897. Authority, South Penn Oil Company.

	Feet.
Waynesburg coal, at	195
Sewickley coal, at	454
Pittsburg coal, at	535
Unrecorded	150 to 685
Sand, Morgantown	95 " 780
Blue and *red* "*cave*"	90 " 870
Shells	15 " 885
Sand	30 " 915
Slate and shells	95 " 1,010
Sand, *Dunkard*	40 " 1,050
Slate	60 " 1,110
Coal, Upper Freeport	2 " 1,112
Slate	93 " 1,205
Coal Upper Kittanning	2 " 1,207
Slate and shells	73 " 1,280
"*Gas sand*," *Freeport*	40 " 1,320
Slate	7 " 1,327
Sand	43 " 1,370
Slate	6 " 1,376
"*Salt Sand*" (*Pottsville, No. XII.*)	169 " 1,545
Slate and shells	55 " 1,600
Red rock	65 " 1,665
Slate and shells	40 " 1,705
Red rock	12 " 1,717
Mountain limestone	38 " 1,755

Big Injun sand, gas ("1st pay") 1882, oil and water ("2nd pay")

1903, water ("3rd pay") 1915	173 to	1,928
Slate	57 "	1,985
Sand ("*Squaw*")	55 "	2,040
Slate and shells	28 "	2,068
Sand, little gas	307 "	2,375
Slate and pebbles	65 "	2,440
Sand (top of *Gantz*)	5 "	2,445
Slate and shells	15 "	2,460
Sand	20 "	2,480
Slate	25 "	2,505
Sand	15 "	2,520
Slate	25 "	2,545
Sand, (bottom of "*Fifty-Foot*,")	5 "	2,550
Red rock	5 "	2,555
Sand	3 "	2,558
Red rock	12 "	2,570
Sand	70 "	2,640
Slate and pebbles	20 "	2,660
Red rock	35 "	2,695
Sand (*Campbell's Run*)	25 "	2,720
Unrecorded	40 "	2,760
Gordon sand (*Whetstone Run sand*)	8 "	2,768
Slate and shells	22 "	2,790
Fourth Sand (*Flat Run sand*)	15 "	2,805
Slate and shells	35 "	2,840
Fifth Sand, McDonald	15 "	2,855
Slate	57 "	2,902
Unrecorded	41 "	2,943
Sixth Sand, Elizabeth, Bayard, etc., oil and gas	6 "	2,949
Slate to bottom	11 6″ to	2,960 6″

Five barrel well.

Total thickness from top of *Gantz* to bottom of *Fifth* or *McDonald* Sand, 415 feet. From top of *Gantz* to bottom of *Sixth* or *Elizabeth* Sand, 509 feet.

These records along the West Virginia-Pennsylvania line demonstrates the continuity of the *Venango Oil Sand Group* southward from Pennsylvania into West Virginia.

We shall now give typical records from each of the great oil producing regions of the State, though the limits of this volume will not permit the introduction of as many as desired.

Those already given will suffice for Monongalia county, and we shall pass southward to Marion, along the line of the "Big Injun" oil belt.

The following record of the Brice Wallace well No. 1, two miles north-east from Fairview, gives the succession of the strata in that region as reported by the South Penn Oil Company:

Brice Wallace Well No. 1.

On the farm of Brice Wallace in Paw Paw District, Marion county, West Va. Authority, South Penn Oil Company.

	Feet.		
Conductor	12	to	12
Slate, white	30	"	42
Coal, Washington	4	"	46
Slate and sandstone	87	"	133
Slate	4	"	137
Coal, Waynesburg "A"	7	"	144
Slate	5	"	149
Sand, white, sharp, *Waynesburg*	40	"	189
Coal, Waynesburg	6	"	195
Limestone	39	"	234
Slate and sandy shell	50	"	284
Limestone	36	"	320
Slate and limestone	60	"	380
Sand, sharp and white	40	"	420
Coal, Sewickley (water)	10	"	430
Slate, soft	25	"	455
Limestone, hard	35	"	490
Slate	30	"	520
Coal, Pittsburg	14	"	534
Slate, white	31	"	565
Limestone	40	"	605
Slate, white	15	"	620
Red rock	25	"	645
Shale and white sandstone	50	"	695
Red rock with sand	165	"	860
Limestone	15	"	875
Red rock and slate	40	"	915
Sandstone	25	"	940
Slate, white (some coal)	30	"	970
Sand, hard	35	"	1,005

Slate, dark	45	to	1,050
Sandstone, *Mahoning*, *Dunkard*	40	"	1,090
Coal and slate, *Upper Freeport*	20	"	1,110
Dark slate and sandstone	160	"	1,270
Sand	30	"	1,300
Slate and sandy shells	60	"	1,360
Sandstone	50	"	1,410
Slate and shells	69	"	1,479
"Salt Sand" (salt water at 1,525)	136	"	1,615
Red rock	140	"	1,755
Slate, dark	25	"	1,780
Limestone, *Mountain*	70	"	1,850
"*Big Injun*" *Sand*: sand, solid 65; limestone 7; sand, (gas, light) 20; sand (heavy gas) 30; sand (oil) 13; sand 7	142	"	1,992
Slate to bottom of well	5	"	1,997

On the P. W. Yost farm, a short distance south-west from Fairview, Marion county, the record of the first well drilled by Mr. Ira DeWitt was kept with considerable detail, and is here given as follows:

P. W. Yost Well No. 1.

On the P. W. Yost farm, near Fairview, Marion county, W. Va. Authority, Ira DeWitt, of Pittsburg, Pa.	Feet.		
Conductor	8	to	8
Sand, *Waynesburg*	62	"	78
Coal, *Waynesburg*	4	"	74
Slate	15	"	89
Limestone, brown and hard	25	"	114
Sand, gray and hard	15	"	129
Limestone, white and hard	50	"	179
" brown and hard	60	"	239
" gray and hard	76	"	315
Sand, gray and hard	40	"	355
Slate, black and soft	13	"	368
Coal (*Mapletown*) *Sewickley*	4	"	372
Limestone, brown and hard	63	"	435
Coal (*Redstone*)	4	"	439
Limestone, brown and hard	13	"	452
Slate, black and soft	10	"	462
Pittsburg coal	10	"	472

Limestone, gray and hard		40 to	512
Slate, light and soft		60 "	572
Limestone, brown and hard		20 "	592
Slate, red and soft		30 "	622
Sand, gray and hard, *Morgantown*, (some gas)		50 "	672
Slate, red and soft		40 "	712
Limestone, brown and hard		25 "	737
Slate, black and soft		50 "	787
Sand, gray and hard		25 "	812
Slate, black and soft		40 "	852
Sand, gray and hard		30 "	882
Limestone, black and hard		25 "	907
Slate, black and soft		15 "	922
Sand, Mahoning (Dunkard) — white and hard 30; gray and hard 60	90	"	1,012
Slate, white and soft	15	"	1,027
Sand, gray and hard (*Upper Freeport*)	65	"	1,092
Limestone, white and hard	28	"	1,120
Lower Freeport, Sandstone 2nd Cow Run. — sand, white 20; " " and soft 13; " " hard 18; " " soft 10	61	"	1,181

(Oil and gas at 1148 ft., started at 7 bbls. per day, in 12 days was not making ½ bbl. Salt water 15 bailers per hour in bottom sand.)

Slate, black and soft	17	"	1,198
Sand, white and hard	25	"	1,223
Limestone, brown and hard	44	"	1,267
Coal	2	"	1,269
Limestone, brown and hard	11	"	1,280
Pottsville Conglomerate No. XII. — sand, white, hard 30; limy sandstone, white, hard 30; slate and shells 60; limestone, white, hard 20; *Salt Sand* (salt water 10 bailers per hour 100)	240	"	1,520
Slate, light and soft	30	"	1,550
Mauch Chunk Red Shale — slate, red 100; slate and shells 40; slate, red and soft 10; slate and shells, blue 15	165	"	1,715
Mountain Limestone — limestone, brown and hard 20; limestone, yellow and hard 40; limestone, gray and hard 10	70	"	1,785
Sand, red and soft	5	"	1,790
Sand, limy, yellow and hard (top of *Big Injun*)	22	"	1,812
Sand, yellow and hard	77	"	1,889
Top of 1st "pay" streak		"	1,889

Very little oil in first "pay"; drilled three bits before got much oil; well

made first flow of 7 inches in 250 bbl. tank while running fourth bit, then run four bits. Sand good, but oil not increasing. 100 barrel well.

At Mannington the first test well was drilled by Mr. A. J. Montgomery of Washington, Pa., on the Hamilton farm, and a careful record was kept of the same As may be seen, it shows a splitting up of the "Big Injun Sand," the upper portion corresponding to the "Keener" division of the Sistersville and other regions of the State. The record reads as follows:

Hamilton Well No. 1.

On the Hamilton farm, near Mannington, Marion county, West Va. Authority, A. J. Montgomery.

		Feet.
Conductor	15 to	15
Coal, Waynesburg "A"	1 "	16
Slate	14 "	30
Sand, blue	35 "	65
Slate	25 "	90
Sand (cased 10-inch at 110 ft.)	30 "	120
Limestone	40 "	160
Slate	35 "	195
Limestone and shale	142 "	337
Slate	8 "	345
Coal, Sewickley	12 "	357
Slate (water and gas at 360)	35 "	392
Limestone	48 "	440
Slate, dark	19 "	459
Coal, Pittsburg	11 "	470
Slate	25 "	495
Limestone, hard	40 "	535
Sandstone, hard	35 "	570
Slate	23 "	593
Sand, hard	4 "	597
Red rock	6 "	603
Shale, variegated, blue and red	87 "	690
Slate, very red	10 "	700
Limestone, slaty	45 "	745
Coal, Crinoidal	5 "	750
Slate, blue	25 "	775
Limestone	10 "	785
Red rock	13 "	798

	Feet.
Limestone and shale	26 to 824
Sand, dark	20 " 844
Slate, dark	31 " 875
Sand (water and gas from 875 to 890)	45 " 920
Slate, gray	65 " 985
Sand, Dunkard, open, sharp, (smell of oil)	92 " 1,077
Slate	93 " 1,170
Sand, hard, dark gray	15 " 1,185
Sandy shells, slate	45 " 1,230
Slate, black (show of coal)	20 " 1,250
Sand, shell, very hard	27 " 1,277
Coal and *slate, Lower Kittanning*	17 " 1,294
Limestone, slaty	21 " 1,315
Sandy shell, very hard	55 " 1,370
"*Salt Sand*," white, pebbly, (salt water at 1385)	117 " 1,487
Slate, dark	31 " 1,518
Sand, dark, pebbly	15 " 1,533
Shale, sandy	37 " 1,570
Slate, light, (show of coal)	30 " 1,600
Shale, red (cased 4⅞-inch at 1680)	78 " 1,678
Blue slate and limestone	28 " 1,706
Red rock, hard	5 " 1,711
Limestone, gray *Mountain*	92 " 1,803
"*Big Injun*" Sand: sand, gray "Keener"... 37 (gas at 1815); limestone, white..... 17; slate, dark..... 10; sand, 1st "pay" 1867, 2nd "pay" 1879..... 61	125 " 1,928

The succession through the oil and gas sands below the "*Big Injun*" down to the *Whetstone Run* "*Gordon*" *Sand* of the drillers in the Mannington region, is shown by the record of the N. S. Beatty well No. 1, as follows:

N. S. Beatty Well No. 1.

On the farm of N. S. Beatty, one mile above Mannington, on the waters of Buffalo creek, Marion county. Authority, South Penn Oil Co.

	Feet.
Conductor	16 to 16
Unrecorded (10-inch casing 400)	434 " 450
Bluff sand (*Waynesburg*)	35 " 485
Unrecorded	313 " 798
Mapletown coal (*Sewickley*)	5 " 803

	Feet.
Unrecorded	105 to 908
Pittsburg Coal	8 " 916
Unrecorded	396 " 1,312
"*Little Dunkard*" *Sand*	38 " 1,350
Unrecorded (cased 8¼-inch at 1,450)	106 " 1,456
"*Big Dunkard*" *sand*	34 " 1,490
Unrecorded	73 " 1,563
"Gas sand," (*Freeport*)	177 " 1,740
Unrecorded	80 " 1,820
"Salt sand" (water at 1,832; cased 6⅝-inch at 1,887)	68 " 1,888
Unrecorded	162 " 2,050
Sand (water at 2,058)	40 " 2,090
Unrecorded	66 " 2,156
"Pencil cave"	8 " 2,164
Big Lime	76 " 2,240
"Break" (slate)	2 " 2,242
"*Big Injun*" sand (water, 2,330′; cased 5 3-16-inch 2,416′ 9″)	168 " 2,410
Unrecorded	420 " 2,830
Gantz sand (gas at 2,845′)	55 " 2,885
"Break" (slate)	10 " 2,895
Fifty-Foot sand	45 " 2,940
Unrecorded	68 " 3,008
Thirty-Foot sand	58 " 3,066
Unrecorded	22 " 3,088
"*Stray*" *sand* (*Campbell's Run*) bottom of liner	32 " 3,120
Gordon sand (*Whetstone Run*) oil at 3,126	24 " 3,144
Bottom of well	" 3,144

Near the head of Whetstone Run, three miles south-west from Mannington, on the farm of J. C. Straight, a well was drilled through the entire Venango Oil Group, and is especially interesting as showing the succession in the lower portion of those beds. It reads as follows, according to Mr. John Kirtland, of the South Penn Oil Company:

J. C. Straight Well No. 2.

On the farm of J. C. Straight, Whetstone Run, three miles south-west from Mannington, Marion county, West Va. Authority, John Kirtland.

	Feet.
Unrecorded	552 to 552
Pittsburg coal	10 " 562
Unrecorded	1338 " 1,900

		Feet
"*Big Injun*" *sand* (show of oil at 1998)	155 to	2,055
Unrecorded	674 "	2,729
White sand "*Stray*" (*Campbells Run* "*Gordon*")	20 "	2,749
Slate	9 "	2,758
Whetstone Run "*Gordon.*" sand, gray, soft 6; sand, white, hard, pebbly (gas at 2765; oil 2766 2; sand 24)	32 "	2,790
Slate	12 "	2,802
Sand (*Flat Run*, "*Gordon*," *Fourth*)	12 "	2,814
Slate, blue	2 "	2,816
Fifth or *McDonald.* sand, gray 6; sand, pebbly (show of gas 2823) 3; sand, blue 15; sand white (show of gas, 2842) 5	29 "	2,845
Slate, black	85 "	2,930
Sand, gray, *Sixth* or *Elizabeth* (show of gas 2931)	3 "	2,933
Black slate and shell to bottom of well	109 "	3,042

The identification of the different sands suggested above is my own, and is held tentatively only, since further study from more data may change the conclusions. It appears almost certain, however, that *three* separate and distinct sands have each received the name of "*Gordon*" by the drillers in the Marion county oil fields, as will appear by the next two records to be given, when compared with the two preceding ones.

The Whetstone Run "Gordon" Sand pool was opened in 1891, by a well (No. 1) on the J. C. Straight farm, 3 miles south-west from Mannington, drilled by A.J. Montgomery and the Jackson Oil and Gas Co. During the next two years the field was fully developed, both north-east and south-west from the Straight farm, and appeared to end near Mannington in the one direction, and Joetown in the other. In searching for an outlet to the pool north from Mannington, the South Penn Oil Co. drilled a well in 1894, on the land of J. A. Thomas, Flat Run, near Condit P. O., and three miles

due north from Mannington. This well proved a large producer in a sand which the drillers called the "Gordon," although it came 2227 feet below the *Pittsburg coal*, instead of 2196 feet as in the Whetstone run pool, and hence it has ever since been known as the "*Gordon.*" The following record of the J. A. Thomas well No. 1, the original well in the Flat Run pool, shows the relations of that producing sand to the other beds of the series:

J. A. Thomas Well No. 1, 1894.

On Flat Run, near Condit Postoffice, three miles north from Mannington, Marion county. Authority, South Penn Oil Co.

Elevation above tide, 1019 feet.	Feet.
Unrecorded to *Mapletown coal* (cased 10″ at 245)	550 to 550
Unrecorded	101 " 651
Pittsburg coal	7 " 658
Unrecorded	518 " 1,176
Sand, *Dunkard*	40 " 1,216
Unrecorded (cased 8¼-inch at 1,281)	126 " 1,340
"*Gas sand*" "*Freeport*"	120 " 1,460
Black slate and limestone	110 " 1,570
"*Salt sand*"	80 " 1,650
Unrecorded	13 " 1,663
Limestone	12 " 1,675
Black sand (cased 6⅝-inch at 1,687)	25 " 1,700
Slate	25 " 1,725
Limestone	25 " 1,750
Unrecorded	50 " 1,800
Red rock	48 " 1,848
Slate, white	10 " 1,858
Limestone	15 " 1,873
Red rock	17 " 1,890
Limestone	5 " 1,895
"Pencil cave"	5 " 1,900
Limestone, *Mountain*	85 " 1,985
'*Big Injun*" *sand* (oil at 2074)	190 " 2,175
Limestone	50 " 2,225
Sand and shells	15 " 2,240
Unrecorded	25 " 2,265
Slate and limestone	55 " 2,320
Limestone and shells	140 " 2,460
Sand	30 " 2,490

	Feet.
Slate	10 to 2,500
Sand and shells [*Gantz*]	20 " 2,520
Shells and slate	70 " 2,590
Sand [*Fifty-Foot*] gas at 2,600	52 " 2,642
Red rock	8 " 2,650
Slate	56 " 2,706
Red rock	27 " 2,755
Slate	35 " 2,790
Red rock	15 " 2,805
Sand and shells	30 " 2,835
"*Stray*" *sand* [*Campbell's Run* "*Gordon*"]	16 " 2,851
Slate	3 " 2,854
Sand, [*Whetstone Run* "*Gordon*"]	29 " 2,883
Slate	2 " 2,885
White sand, Flat Run "*Gordon,*" *oil* at 2890	10 " 2,895

Three-miles north-west from the J. A. Thomas well, the record of which has just been given, the South Penn Oil Co. drilled in a large well on the land of John Styles, early in the year 1897, on Campbell's Run. The producing sand was found at a depth of only 2156 feet below the *Pittsburg coal*, but the drillers called it the "*Gordon*" all the same, although it occupies the exact position of their "*Stray*" sand in the Thomas well just given, and also of the "*Stray*" above the *Whetstone Run* "*Gordon,*" thus giving the same name to three separate and distinct sand horizons. This will be readily discovered by any one who will compare the two records already given from Whetstone run and Buffalo creek (J. C. Straight No. 3, and N. S. Beatty No. 1,) with the J. A. Thomas No. 1, just given, and also with that of the John Styles No. 1, the first well completed on Campbell's Run, as follows:

John Styles Well No. 1.

On the farm of John Styles, Campbell's Run, Marion county. Authority, South Penn Oil Co.

Elevation above tide 1046.		Ft.
Conductor	16 to	16
Lime shells and red rock (cased 10-inch 282)	694 "	710
Mapletown coal (*Sewickley*)	"	.....
Unrecorded	105 "	815
Pittsburg coal	7 "	822
Unrecorded	493 "	1,315
Dunkard sand (*Mahoning*) cased 8¼ at 1324	85 "	1,400
Slate	40 "	1,440
"Gas sand" (*Freeport*)	80 "	1,520
Slate and shell	220 "	1,740
"Salt sand"	80 "	1,820
Red rock and shell (*Mauch Chunk*)	240 "	2,060
"*Big Lime*" (cased 6⅝ at 2120)	80 "	2,140
Big Injun sand (gas at 2160)	140 "	2,280
Unrecorded	300 "	2,580
"*Thirty-Foot*" sand	20 "	2,600
Unrecorded	140 "	2,740
Gantz Sand	12 "	2,752
Red rock	23 "	2,775
"*Fifty-Foot*" { sand 20 / slate 15 / sand 15 }	50 "	2,825
Slate and shells	50 "	2,875
Sand	10 "	2,885
Red rock	15 "	2,900
Limestone and sand shells	25 "	2,925
Red rock	5 "	2,930
Stray "*Thirty-Foot*" proper	35 "	2,965
"Pencil cave"	13 "	2,978
"*Gordon*" *sand* (*Campbell's Run* "*Gordon*")	32 "	3,010
1st "pay" 2983; 2nd "pay" 2987; 3rd "pay" 2992		
Bottom of well		3010

Here the driller has introduced a new "Thirty-Foot" sand, *above* the *Gantz* horizon, and then to make the sands come out right below he has termed the true "Thirty-Foot," the "Stray," since the "Thirty-Foot" sand occupies about the same relation to the "*Stray*" *sand* in the Whetstone and Flat Run pools, that the true "*Stray*," the *Campbell's Run oil sand* of the Styles well, does to the *Whetstone Run* "*Gordon*" *sand* below.

Passing southward now into Harrison county, we find some changes in the character of the rocks. The

"*Big Injun*" becomes limy and no longer holds oil, while the changes in other important strata are shown by the following record of a well drilled on the land of Seth Piggott, Sardis District, near the head of Laurel Run, one mile west from the Marion county line:

Seth Piggott Well No. 1.

Drilled in 1894, on the farm of Seth Piggott, Laurel run, Sardis district, Harrison county. Authority, South Penn Oil Co.

			Feet.
Conductor	14	to	14
Limestone, hard	3	"	17
Slate	43	"	60
Coal, (*Washington*)	2	"	62
Sand	38	"	100
Limestone	100	"	200
Red rock	50	"	250
Unrecorded	235	"	485
Limestone and slate	105	"	590
Pittsburg coal	8	"	598
Limestone and slate	102	"	700
Red rock	100	"	800
Slate	60	"	860
Red rock	15	"	875
Sand	30	"	905
Limestone	55	"	960
Sand, white	95	"	1,055
Limestone	13	"	1,068
Slate	12	"	1,080
Limestone	10	"	1,090
Sand	55	"	1,145
Sand, white	55	"	1,200
Limestone	44	"	1,244
Slate and limestone	26	"	1,270
Slate, black	30	"	1,300
Sand	270	"	1,570
Limestone	35	"	1,605
Sand, white	95	"	1,700
Slate, black	48	"	1,748
Sand	20	"	1,768
Limestone and slate	87	"	1,855
"Pencil cave"	6	"	1,861
Big Limestone	51	"	1,912

			Feet.
"Big Injun" Sand { soft sand and limestone, (gas at 1,937) ..... .60 / hard sand ..... .20 }	..80	"	1,992
Limestone	.168	"	2,160
Slate	40	"	2,200
Slate and limestone	100	"	2,300
Sand and limestone	50	"	2,350
Limestone	50	"	2,400
Slate	90	"	2,490
Gantz sand, (gas at 2,495)	20	"	2,510
Slate	15	"	2,525
"Fifty-Foot" sand	10	"	2,535
Slate	55	"	2,590
Limestone	10	"	2,600
Red rock	25	"	2,625
Sand	25	"	2,650
Limestone	10	"	2,660
Sand	10	"	2,670
Limestone	10	"	2,680
Sand and limestone, (*"Thirty-Foot"*)	48	"	2,728
Slate	3	"	2,731
Campbell's Run { sand, pebbly (oil at 2,731) ..... 5 / sand, hard ..... 14 }	... 19	"	2,750
Slate	10	"	2,760
Whetstone Run sand (gas at 2,765)	20	"	2,780
Limestone and slate	20	"	2,800
Flat Run sand	2	"	2,802
Slate and limestone	199 9″	"	3,001 9″

The well made quite a good showing of oil from what appears to be the *Campbell's Run sand* at 2,731 feet, but the production fell off rapidly and the well was abandoned as unprofitable.

Still further south-west, a well was drilled on the land of I. L. Marsh, near Brown's Mills, Little Ten Mile creek, by White and Jackson in 1890. The record was kept through the "Big Injun" sand with considerable care, and reveals the following succession:

Brown's Mill Well.

Land of I. L. Marsh, near Brown's Mill, Sardis District, Harrison county W. Va. Authority, W. H. Nicholson, contractor.

		Feet.
Conductor	10 to	10
Sandstone, white, *Waynesburg*	25 "	35
Coal, Waynesburg	3 "	38
Slate	15 "	53
Sandstone, hard, white, (cased 10-inch at 93 ft.)	35 "	88
Slate, soft	80 "	168
Coal, Uniontown	5 "	173
Limestone, hard	30 "	203
Slate, soft, white	15 "	218
Limestone, hard, blue	112 "	330
Slate, soft, black	60 "	390
Limestone, hard	15 "	405
Slate, white	33 "	438
Pittsburg coal	10 "	448
Slate and sand	232 "	670
Red rock and "cave"	40 "	710
Sand	15 "	725
White slate and shells	65 "	790
Sand, hard, dark	30 "	820
Slate and shells, hard, and limy-(cased 7⅝″ at 966′ 6″)	140 "	960
Dunkard sand, white (gas at 970, blackish oil at 975)	80 "	1,040
Black slate and shells to top of *Salt sand*	300 "	1,340
"Salt Sand": sand, white 30; slate, black 30; sand, black, close 10; sand, white, hard 5; slate, black 10; sand, black 55; sand, white, solid 102	242 "	1,582
Slate and shells	8 "	1,590
Limestone and slate	10 "	1,600
Limestone, hard	30 "	1,630
Red rock	15 "	1,645
Slate, black, and shells	37 "	1,682
Limestone, hard, blue	6 "	1,688
Limestone and shells	12 "	1,700
Red rock	5 "	1,705
Black slate, cave, "Pencil"	11 "	1,716
Limestone, light gray (cased 5⅜-inch)	49 "	1,765
Sand, gray, "*Big Injun*," top	7 "	1,772
Limestone, gray	32 "	1,804
Slate, black	4 "	1,808
Limestone, gray	14 "	1,822
Sand, white, soft at top (gas at 1833′)	40 "	1,862
Hard shell, pebbly at bottom, gray	5 "	1,867

The *Dunkard* or *Mahoning* sand at 975 feet produced

some oil, and may possibly furnish paying wells in the region, but the "*Big Injun*" sand horizon has changed largely to limestone, and hence is unproductive.

About four miles south-west from Brown's Mill, and a mile and a half west from Marshville, in Ten Mile District, Harrison county, a well was bored on the M. A. Dennison land by the South Penn Oil Company, where the following record of the strata passed through has been furnished by that Company:

M. A. Dennison Well No. 1.

Waters of Grass Run, Ten Mile District, Harrison Co., W. Va. Authority, South Penn Oil Company.

	Ft.		
Unrecorded	500	to	500
Pittsburg coal	8	"	508
Unrecorded	1,317	"	1,825
"*Big Injun*" *Sand*	125	"	1,950
Slate	25	"	1,975
Limestone	30	"	2,005
Sand, lime and shells	139	"	2,144
Slate and shells	101	"	2,245
Limestone	50	"	2,295
Slate	100	"	2,395
Gantz Sand (small gas at 2415′)	40	"	2,435
Slate	30	"	2,465
Sand and shells ("*Fifty-Foot*")	30	"	2,495
Sand	60	"	2,555
Slate	20	"	2,575
"*Thirty-Foot Sand*" (oil show at 2590′)	25	"	2,600
Slate	10	"	2,610
Sand and shells	30	"	2,640
Sand, Campbell's Run "*Gordon*"	19	"	2,659
Slate and shells to bottom	109	"	2,750

The "*Thirty-Foot*" sand of this well struck at 2067 feet below the *Pittsburg coal* gave quite a nice show of oil in the Dennison well, and had the rock been treated to a shot of glycerine, it might have made a productive well. This same rock produced a fair gas well on the

Lynch farm, near Cherry Camp, where it was 37 feet thick, coarse and pebbly, and struck at 2808 feet, or 2082 feet below the Pittsburg coal.

One-half mile south-east from the Lynch well, this "*Thirty-Foot*" *sand* was struck at 2770 feet in the Nathan Goff No. 2, or 2064 feet below the *Pittsburg coal*, where it was 38 feet thick with 10 feet of slate just below the center, and showing neither oil nor gas. But in the Goff No. 1, 1500 feet south-east of No. 2, where it was struck at 2556 feet, 2082 feet below the *Pittsburg coal*, it made quite a good showing of oil in the upper 11 feet, below which was 6 feet of slate and then 40 feet of sand with gas. In each of these three wells (Lynch No. 1 and Goff Nos. 1 and 2) this sand was found only a few feet (0′-13′) below 25 to 40 feet of red rock.

Three or four miles south-east from Cherry Camp, and near Miletus, in Doddridge county, this same sand proved a fair gasser in a well drilled on the Maxwell land, where it was 30 feet thick and struck at 2670 feet, 2083 feet below the *Pittsburg coal.*

The Jarvisville oil pool is found in one of the deep sands and appears to be the *Fifth* or *McDonald*, so far as one can judge from the following records in that field as given by the South Penn Oil Company. The locality is in Ten Mile District, of Harrison county, and about two and a half miles from Cherry Camp.

The record of the L. E. Stout well No. 1 reads as follows:

L. E. Stout Well No. 1.

Jarvisville oil pool, Ten Mile District, Harrison county, W. Va. Authority, South Penn Oil Company.

			Feet.
Unrecorded	325	to	325
Pittsburg coal	.....	"	.....
Unrecorded (water at 1,655′)	1,430	"	1,755
"*Big Injun*" sand	80	"	1,835
Unrecorded	555	"	2,390
"*Stray*," ("*Thirty-Foot*"), gas 2,410	25	"	2,415
Unrecorded	10	"	2,425
"*Gordon*" *sand*	.....	"	.....
Unrecorded	115	"	2,540
Fourth Sand, (*Flat Run*)	.....	"	.....
Unrecorded	93	"	2,633
Fifth Sand, McDonald, (oil at 2,638)	.....	"	.....
Total depth	.....	"	2,660

In the Genius Payne well No. 3, of the same region the succession is as follows, according to the South Penn Oil Company:

Genuis Pagne Well No. 3.

			Feet.
Unrecorded	503	to	503
Pittsburg coal	8	"	511
Unrecorded	439	"	950
Dunkard sand	25	"	975
Unrecorded	55	"	1,030
Sand, *Lower Dunkard*	20	"	1,050
Unrecorded	518	"	1,568
"*Salt Sand*"	112	"	1,680
Unrecorded	103	"	1,783
Red rock.	44	"	1,827
Unrecorded	13	"	1,840
"*Big Injun*" Sand { "*Keener*" 22; "*Big Lime*," (part of "*Injun*") 96; "*Injun*" sand 47 }	165	"	2,005
Unrecorded	195	"	2,200
Sand	25	"	2,225
Unrecorded	195	"	2,420
"*Fifty-Foot*" Sand { sand 10; break 10; sand 18 }	38	"	2,458
Unrecorded	142	"	2,600
"*Stray*," ("*Thirty-Foot*"), oil and gas at 2,600′	.....	"	.....
Unrecorded	43	"	2,643
"*Gordon*" (*Campbell's Run Sand*)	17	"	2,660

			Feet.
Unrecorded	45	to	2,705
Fourth Sand (Flat Run Sand)	...	"	.....
Unrecorded	90	"	2,795
Fifth Sand, McDonald, dry	4	"	2,799
Unrecorded to bottom	40	"	2,839

The Edith Starkey well No. 1 in the same field gives another variation as follows, according to the same authority :

Edith Starkey Well No. 1.

			Ft.
Unrecorded	332	to	332
Pittsburg coal	.....	..	.....
Unrecorded	1,455	"	1,787
" Big Injun " Sand	.....	..	.....
Unrecorded	633	"	2,420
" Thirty-Foot " Sand — *" Stray "* 10; break ...; *" Gordon "* 20	30	"	2,450
Unrecorded	100	"	2,550
Fourth Sand (Flat Run)	...	..	.....
Unrecorded	88	"	2,638
Fifth Sand, McDonald	7	"	2,645
Unrecorded to bottom	32	"	2,677

In these 3 wells, (Stout No. 1, Payne No. 3, and Starkey No. 1,) the drillers have termed the " *Thirty-Foot* " sand, the " *Stray*," and the first sand under it (which is really a part of it,) the " *Gordon.*" The top of the " *Thirty-Foot* " comes at 2065, 2089 and 2088 feet below the Pittsburg coal in these wells, and hence it is unquestionably the same which produced oil and gas in Goff No. 1, and gas in Lynch No. 1, and which has been identified in nearly every deep well from the State line southward. From these records we also perceive that the entire *Venango Group* is represented in the Jarvisville pool, and that although the " *Big Injun* " *Sand* is represented, it has changed largely to

limestone, and hence that the driller's "*Big Lime*" of the Payne No. 3 is *below* where that stratum should properly come, which when present is immediately on top of what he has rightly termed the "Keener" sand in the same record.

Passing now still further east into Lewis county, we find the following succession of the rocks on the Summers farm, Stone Coal Run, 10 miles south-east from Weston, according to Mr. C. E. Griffiths, of Pittsburg, Pa., who drilled the well in 1896:

Summers Well No. 1.

Pittsburg coal 220 feet above the derrick floor, according to Mr. F. H. Oliphant.

		Feet.
Surface, brown, soft	15 to	15
Gravel, brown, soft	10 "	25
Red, soft	125 "	150
Brown, soft	75 "	225
Slate to lime, white, hard and soft	250 "	475
Mahoning: sand, white, hard 30; slate and shell, white, hard 20; sand, white, hard 30	80 "	555
Coal, soft, (water) *Upper Freeport*	12 "	567
Sand, white, hard	20 "	587
Slate, white, soft	13 "	600
Sand, gray, hard	30 "	630
Slate, brown, soft	5 "	635
Sand, gray, hard	5 "	640
Coal, soft, (water) *Lower Freeport*	5 "	645
Sand, gray, hard (water)	95 "	740
Slate and limestone, brown and hard	68 "	808
Sand, gray, hard	15 "	823
Limestone, pale brown, hard	17 "	840
Sand, gray, pebbly	20 "	860
Slate, black and soft	10 "	870
"Salt Sand" No. XII.: sand, gray, hard 45; slate, black, soft 55; limestone, blue, hard 20; sand, gray, hard 50; limestone, blue, hard 10; sand, white and yellow, hard 150	330 "	1,200
Red rock, soft, "*Mauch Chunk*"	100 "	1,300

"Big Injun" and *"Squaw" Sand*	sand, light gray, hard, (water) (cased 6¼-inch)	65	210 to 1,510
	limestone, dark brown	30	
	limestone, gray	5	
	limestone, white	50	
	limestone, brown	15	
	sand, gray	5	
	limestone, white	30	
	sand, gray	10	
Red rock		5	" 1,515
Limestone, white		55	" 1,570
Sand, white		10	" 1,580
Limestone, dark gray		10	" 1,590
Limestone, black		10	" 1,600
Slate and shell		50	" 1,650
Sand, white		10	" 1,660
Slate, black		5	" 1,665
Sand, white		10	" 1,675
Slate, black		5	" 1,680
Sand, white, *Gantz*		90	" 1,770
"Fifty-Foot" sand	slate, black, soft	5	95 " 1,865
	sand, white, hard	60	
	slate, black, soft	5	
	sand, white, hard	25	
Red rock, and sand shells, red and gray		115	" 1,980
Sand, gray and white (*Fourth*)		70	" 2,050
Slate and shells, white and brown		90	" 2,140
Sand, white and pebbly (show of oil) *Fifth*		20	" 2,160
Slate, black, soft		5	" 2,165
Sand, white, hard		15	" 2,180
Slate and shells, black		60	" 2,240
Slate and shells, black and white		10	" 2,250
Slate, white, soft		40	" 2,290
Slate, white, hard		10	" 2,300
Slate, white to bottom		101	" 2,401

The sand at 2140 feet which comes 2360 feet below the *Pittsburg* coal, that crops out in the hills 220 feet above the derrick floor, had quite a nice show of oil, and it would appear to be identical with the producing sand near Jarvisville, Harrison county, or the equivalent of the *Fifth* or *McDonald* sand. The gas well 2 miles below Weston on the Woodford farm was struck in this same *Fifth sand*.

The *Mountain Limestone* appears to be absent, and the "*Big Injun*" below is very limy. The *Gantz* and

"*Fifty-Foot*" beds come at their proper horizons but both are greatly thickened.

About 20 miles south-west from the Jarvisville pool some oil has been developed at the head of Fink creek, near Vadis P. O., Lewis county, close to the line separating Lewis, Doddridge and Gilmer. The first well was drilled there by the South Penn Oil Company in 1894 on the farm of John Rastle. The well starts about 40 feet under what is either the *Waynesburg* or *Uniontown coal* (most probably the latter), and gives the following succession, according to the South Penn Oil Company's record:

John Rastle Well No. 1.

		Feet.
Conductor	31 to	31
Sand	12 "	43
Red rock	76 "	119
Limestone	71 "	190
Slate	30 "	220
Limestone	20 "	240
Slate	15 "	255
Limestone	10 "	265
Slate	29 "	294
Coal, Pittsburg	8 "	302
Slate	36 "	338
Sand	65 "	403
Red rock	125 "	528
Sand, (*Morgantown*)	89 "	617
Slate	47 "	664
Red rock	38 "	702
Sand	30 "	732
Slate	21 "	753
Sand	39 "	792
Slate	23 "	815
Limestone	70 "	885
Limestone and shells	55 "	940
Slate	25 "	965
Limestone	32 "	997
Slate	20 "	1,017
"Gas sand" (*Freeport*)	83 "	1,100

		Feet.
Slate	25 to	1,125
Limestone	15 "	1,140
Slate	30 "	1,170
Sand	20 "	1,190
Slate	7 "	1,197
Sand	18 "	1,215
Slate	45 "	1,260
"*Salt Sand*" ..... sand 80, slate 67, sand 53	200 "	1,460
Slate	10 "	1,470
Limestone	20 "	1,490
Slate	30 "	1,520
Limestone	20 "	1,540
Slate	75 "	1,615
Sand	15 "	1,630
Limestone	30 "	1,660
Red rock	2 "	1,662
Limestone	18 "	1,680
Sand	15 "	1,695
Red rock	5 "	1,700
"*Big Lime*"	35 "	1,735
"*Big Injun*" *sand*	196 "	1,931
Slate	15 "	1,946
Sand	114 "	2,060
Slate	93 "	2,153
Sand, oil, gas and water, (*Gantz, Berea*)	49 "	2,202
Slate	5 "	2,207
Limestone	33 "	2,240
Slate and shells	463 "	2,703

The driller appears to have made the "*Big Injun*" sand too thick in the Rastle well, since another record on the land of Christian Albers, just across the Lewis county line in Doddridge gives the following measurements, according to the South Penn Oil Company :

Christian Albers Well No. 1.

		Ft.
Unrecorded	324 to	324
Pittsburg coal	....	.....
Unrecorded	1,414 "	1,738

	Feet.
"*Big Injun*" *Sand* (show of oil at 1890')	152 to 1,890
Unrecorded	281 " 2,171
Gantz Sand, (*Berea*) oil 2176, water 2178	30 " 2,201
Unrecorded to bottom	6 " 2,207

Salt water occurs with the oil or so close to it, that it is impossible to separate the same, as in the "*Hundred-Foot*" field of Butler county, Pennsylvania, and the horizon which has been identified with the *Gantz* of the *Washington County group* would appear from its relations to the "*Big Injun*" above to be the same as the "*Berea*" of Wood county, West Virginia, and the Macksburg region of Ohio.

At Washington, Pennsylvania, where the *Gantz sand* was first named, its top lies exactly 1800 feet below the *Pittsburg coal*, and in the typical section of the McDonald, Pa., region, S. B. Phillips No. 1, already given on pages 214-226, its top lies 1842 feet below the same horizon, while the Rastle well above gives this interval at 1851, and the Albers, 1847. Further to the northeast in Marion and Monongalia, this interval increases to 1900 feet, as shown by the records already given for those regions.

Passing from the Rastle oil pool nearly south fifteen miles to Glenville, Gilmer county, we find a considerable change in all the strata, due to the setting in of the great south-eastward thickening of the Coal Measure beds. A well was drilled in 1892 on the Norris farm in Glenville by Messrs. Harris, Caldwell and others of Parkersburg, and the following record of the well which begins about 180 feet under the Pittsburg coal was kept by Mr. G. W. Porter, one of the drillers:

Glenville Well.

			Feet.
Conductor	12	to	12
Red Shale	31	"	43
Blue sand	7	"	50
Red shale	110	"	160
Blue shale (cased 7⅝ inch at 170 ft.)	50	"	210
White shale	20	"	230
Blue sand	10	"	240
Blue shale	24	"	264
Coal (*Masontown*)	6	"	270
Blue shale	45	"	315
White sand with strong oil smell, *Dunkard Mahoning*	39	"	354
Blue shale and lime shells	126	"	480
White sand	80	"	560
Blue shale	20	"	580
Gray sand (*Freeport*, "*Gas Sand*")	70	"	650
Sandy shale	23	"	673
Coal, Lower Kittanning(?)	14	"	687
Black shale and good flow of *gas*	8	"	695
Fine white sand and *gas*	18	"	713
Coal	3	"	716
Black shale	8	"	724
Gray sand	11	"	735
Black shale	235	"	970
White sand and *gas*, top No. XII	164	"	1,134
Black and blue slate	32	"	1,166
White sand, oil in bottom (*Cairo*, *Maxton*)	24	"	1,190
Black shale, base of No. XII	50	"	1,240
Blue shale, top of *Mauch Chunk*	25	"	1,265
Red rock	30	"	1,295
Blue shale and hard lime shells	15	"	1,310
Red rock	20	"	1,330
Lime and sand shells	6	"	1,336
Red rock	39	"	1,375
Black limestone, very hard	23	"	1,398
"Pencil slate" (caving material)	6	"	1,404
Blue limestone ("break" at bottom with gas and oil)	57	"	1,461
"*Big Injun*" *sand*, broken and limy, some black oil and gas at top		"	
Unrecorded	629	"	2,090
Red shale (red rock above "Gordon" sand horizon)	15	"	2,105
Blue shale, with an occasional sandy "shell" to bottom of hole	307	"	2,412

Here the "*Big Injun*" horizon is practically all *limestone*, though its *oil and gas* "pay streak" remains at

1,461 feet and the only recognizable element in the *Venango Oil Sand Group* is the 15 feet of *red shale* at 2090 feet, which belongs just above the several "Gordon" sand horizons of Monongalia, Marion and Harrison counties to the north-east.

Burning Springs, in Wirt county, where the modern petroleum industry first began in West Virginia, is situated about 28 miles north 20° west from Glenville, and we have as yet no records of deep wells drilled between the two points, though many have been drilled through the "*Big Injun*" *Sand* in Calhoun county, where the rock, as well as the "*Salt Sand*" above, has furnished some oil and gas, the latter in large quantity.

Near Burning Springs village, the Roberts Brothers, oil operators, drilled a well through all the sands, and and they kept a very careful record of the same which has been kindly placed at the disposal of the Survey by Mr. L. R. Roberts. The well is situated on Burning Springs Run, 2¼ miles by county road from its mouth at the Little Kanawha river, and about 500 yards east from the crest of the Burning Springs-Eureka anticlinal, which has here hoisted the Pittsburg coal horizon, (though the coal itself is absent,) about 325 feet above the floor of the derrick. The well is located on the Roberts farm, and starts 20 feet below the Crinoidal coal, or 25 feet below the Green Crinoidal Limestone, which, filled with its characteristic marine fossils overlies the coal in question by only a few feet, and often rests immediately upon it. The record reads as follows:

Record of Roberts Well No. 1.

Near Burning Springs, Wirt county, W. Va.

		Feet.
Conductor and *red shale*	60 to	60
Limestone, very hard	6 "	66
Red and blue shales	69 "	135
Sand (water and paraffine)	10 "	145
Blue shales, soft	99 "	244
Sand, *Dunkard*, (*Mahoning*) good show of oil (Cow Run ?)	71 "	315
Gray and blue shales	57 "	372
Sand	31 "	403
Shale	33 "	436
Sand, gray, shelly, *oil show at base* ("Gas sand," 2nd Cow Run ?)	55 "	491
Shale, gray	79 "	570
Sand	60 "	630
Shale, blue and gray	118 "	748
"*Salt Sand*," upper member, good gas flow (2½ million feet)	58 "	806
Shale	14 "	820
"*Salt Sand*," lower member, *Cairo*, or *Maxton Sand*	110 "	930
Limestone, ("*Big Lime*") very hard, lower half mixed with sand	115 "	1,045
"*Big Injun*" sand, *fair oil show*	50 "	1,095
Shale, gray	385 "	1,480
Black shale, mixed with sand ("*Berea*") and showing *oil*	10 "	1,490
Shale, gray	385 "	1,875
Black shale, lower half mixed with *sand* ("*Gordon*"), showing *oil*	15 "	1,890
Shale, very soft in lower portion to bottom of well	120 "	2,010

The sand at 244 feet in this well is the one which first produced so largely at Burning Springs during the early oil drilling craze in 1860. It is certainly the same stratum as the *Dunkard Sand* of Greene county, Penna., but whether or not it is identical with the *1st Cow Run Sand* of Ohio, is not so clear. There is another very massive sand rock 35 to 40 feet thick which makes a great cliff on the bank of the Little Kanawha, just at the mouth of Burning Springs run. Its place is 40 to 50 feet above where the Roberts well begins, occupying the same horizon as the *Morgantown sandstone*, or the "*shallow oil*" *sand* at the mouth of

Island Run, Ritchie county, and it is barely possible that this sand is the old *First Cow Run* of Ohio, although the driller has applied the name "*First Cow Run*" to the *Dunkard*, or *Mahoning* sandstone, far below the Morgantown horizon. If Mr. F. W. Minshall is correct in his identification of the *Pittsburg coal* as cropping 40 to 50 feet above the level of the old wells on Cow Run, then the *sand* struck there at 137 feet in the well drilled by John Newton and others in 1861 on the Samuel Dye land, must be the equivalent of the *Morgantown Sandstone* and *not* of the *Upper Mahoning Sandstone*, the true *Dunkard oil sand*, with which the *First Cow Run Sand* is so often confounded. This point will be investigated later in the history of the Survey and cleared up.

It is quite probable that the main body of the *limestone* struck at 930 feet should really be classed with the "*Big Injun*" *Sand* horizon instead of the *Mountain Limestone*, of Marion and Monongalia, where the *red Mauch Chunk* beds are present.

The oil found between 1480 and 1490 feet unquestionably represents the "*Berea Grit*" horizon of Wood county, and Macksburg, Ohio, and estimating the *Pittsburg coal* horizon as 325 feet above the derrick floor, would place the oil sand in question 1805 feet below that coal, a result agreeing sufficiently close with the measurements in the *Rastle pool*, to demonstrate that these two oil horizons are practically the same.

The *oil* sand at 1890 feet is called "*Gordon*" by Mr. Roberts, and it certainly belongs down in that portion of the *Venango Oil Sand* Group, though as to which particular sand, whether the "*Gordon*" *Fourth* or *Fifth*, it may represent, no one can yet determine.

Passing southward fifteen miles from Burning Springs to Spencer, in Roane county, we get the record of another deep well drilled on the grounds of the State Hospital for the Insane, by Messrs. John Shay, J. T. Harris, and others of Parkersburg. The record was kept with considerable care by Mr. William Cale, the contractor, of Parkersburg, and reads as follows, beginning 87 feet below the *Washington coal:*

Asylum Well No. 1.

On the Asylum farm near Spencer, Roane county, West Va. Authority, William Cale.

		Feet.
Washington coal, 87 feet above derrick floor.		
Sand, white, soft	10 to	10
Limestone, blue, hard	25 "	35
Red rock, soft	25 "	60
Limestone, blue, hard	60 "	120
Slate, white, soft	20 "	140
Red rock, soft	30 "	170
Sand, white, hard	10 "	180
Limestone, dark, hard	18 "	198
Red rock, soft (a show of coal)	17 "	215
Limestone, white, hard	30 "	245
Sand, white, hard	45 "	290
Red rock, soft	25 "	315
Limestone, blue, hard	30 "	345
Red rock, soft	12 "	357
Slate, black, soft	5 "	362
Limestone, blue, hard	25 "	387
Sand, gray, hard	38 "	425
Slate, white, soft	5 "	430
Limestone, white, hard	4 "	434
Slate, black, soft (caves some)	50 "	484
Sand, dark, hard	16 "	500
Slate, white, soft	15 "	515
Slate, red, soft (very soft and cavy)	140 "	655
Limestone, white, hard	25 "	680
Slate, dark, soft	5 "	685
Slate, white, hard, shelly	20 "	705
Limestone, blue, hard	15 "	720
Limestone, white, soft	17 "	737
Slate, red, soft	23 "	760

			Feet.
Limestone, gray, hard	10	to	770
Slate, white, soft	33	"	803
Sand, blue, hard	24	"	827
Slate, white, soft	20	"	847
Limestone, blue, hard	10	"	857
Sand, white, hard on top, little water at 950 (*Mahoning*)	130	"	987
Slate, white, soft	10	"	997
Limestone, blue, hard	20	"	1,017
Sand, white, hard	20	"	1,037
Limestone, white, hard	10	"	1,047
Slate, black, soft	25	"	1,072
Limestone, dark, hard	15	"	1,087
Slate, white, soft	18	"	1,105
Sand, white, hard, ("*Gas Sand*")	85	"	1,190
Slate, black, soft	5	"	1,195
Sand, white, hard	29	"	1,224
Slate and coal, soft (*Kittanning*)	10	"	1,234
Sand, white, hard	41	"	1,275
Slate, black, soft	25	"	1,300
Limestone, black, soft	20	"	1,320
Slate, white, shelly	40	"	1,360
Sand, dark, hard	10	"	1,370
Slate, white, shelly	35	"	1,405
Slate, dark, red(?)	5	"	1,410
Slate, white, shelly	15	"	1,425
Slate, black, very soft	17	"	1,442
Limestone, gray, soft, (probably gray shale)	57	"	1,499
Slate, black	4	"	1,503
Limy sand, white, oily smell	45	"	1,548
Slate, black	5	"	1,553
"*Salt Sand*" { sand, gray (water at 1600, big flow at 1700) 262; sand, fine and dark, bottom of No. XII 15 }	277	"	1,830
Slate, brown	8	"	1,838
Sand, very fine, dark	12	"	1,850
Limestone, gray, (*Mountain*)	30	"	1,880
Limestone, gritty, gray (top of "*Big Injun*")	45	"	1,925
Slate, blue (hard shell at 2200 feet)	325	"	2,250
Slate, white	150	"	2,400
Sand, shell, hard, oil show (*Berea*)	10	"	2,410
Slate, white	90	"	2,500
Slate, blue, hard shells, to bottom	250	"	2,750

This record is rather puzzling, since the drillers evidently mistook the character of the rocks at 1405′ and

also at 1442′. No *red shale* is probable at the former horizon, and should any such body of *limestone* as that reported at the latter level have been encountered, it is safe to say it would not have been "soft," hence I think it most probable that the drillers mistook the character of the strata, since there can be very little doubt that the great salt water sand struck at 1552 feet is not the "*Big Injun*" as at first supposed, but the basal portion of the *Pottsville, No. XII,* or "*Salt Sand*" of the drillers, which is here beginning to thicken rapidly to the south, since only 40 miles from Spencer, along Elk river, near Sutton, it is more than 700 feet thick, and 25 miles further to the south at Camden-on-Gauley is over 1,000 feet.

About ten miles south-west from Spencer, and on the head waters of the Flat Fork of Poca creek, in Roane county, a small pool of oil and gas has been developed by the Eastern Oil Company and the McCalmont Oil Company, during 1897 and 1898. Three or four fair-sized gas wells have been found, and the same number of small oil wells, (5 to 10 barrels) and numerous dry holes. There has been a difference of opinion as to the *sand horizon* in which the oil and gas occur, some inclining to the view that the producing rock belongs in the "*Salt Sand*" *series, No. XII,* while others incline to the belief that it is in the "*Big Injun*" *Sand,* the McCalmont Oil Company espousing this opinion, and the South Penn Oil Company the former.

The record of one of these wells, drilled on the Hughes farm by the McCalmont Oil Co., is given below through the courtesy of Mr. David Kirk, President of that corporation, as follows:

Hughes Well No. 1.

On the Hughes farm, 10 miles south-west from Spencer, Roane county, West Va. Drilled by the McCalmont Oil Company, David Kirk, President, authority.

		Feet.
Washington coal 90 feet above well head, according to Mr. Kirk.		
Unrecorded	275 to	275
Sandstone	60 "	335
Unrecorded	100 "	435
Sandstone	35 "	470
Red shale	35 "	505
Unrecorded	330 "	835
Sandstone (*Dunkard ?*) little oil	10 "	845
Unrecorded	75 "	920
Sandstone	40 "	960
Unrecorded	45 "	1,005
Sandstone	40 "	1,045
Slate, black	30 "	1,075
Sandstone, (show of dark oil)	66 "	1,141
Slate, black	18 "	1,159
Sandstone, pebbly for 35 feet	60 "	1,219
Slate, black	58 "	1,277
Sandstone, mixed with limestone	29 "	1,306
Shale, gray and black	87 "	1,393
Limestone	31 "	1,424
Sandstone (gas at 1,438′; oil spray at 1,458′)	35 "	1,459
Slate	4 "	1,463
Sand, (salt water at 1,535) to bottom	160 "	1,623

In the driller's log of the well, the great salt water rock struck at 1,463 feet, is termed the "*Big Injun*" *sand*, but I think this is only the basal portion of the *Pottsville Conglomerate*, or "*Salt Sand*" of which the oil and gas bearing rock, at 1,438 and 1,458 is one of the upper members. The 160 feet of sand in which the well stopped is the upper portion of the 262-foot sand struck in the Spencer well at 1,553 feet. The Hughes well probably starts further below the *Washington coal* than Mr. Kirk has supposed, since the same strata are found about 50 to 60 feet nearer the surface in the Hughes well, than in the Asylum well at Spencer.

On the Harper farm, a mile or so distant from the Hughes well, just described, another well was completed by the McCalmont Oil Company, having been drilled several hundred feet deeper than that on the Hughes farm. The record of the Harper well is as follows, as given Mr. Kirk by the field superintendent of the McCalmont Company :

Harper Well No. 1.

On the Harper farm, in Roane county, West Va. Authority, McCalmont Oil Company, David Kirk, President.

		Feet.
Unrecorded	861 to	861
Cow Run Sand (*Dunkard*)	25 "	886
Slate	19 "	905
"*Stray Salt*"	42 "	947
Slate, black	73 "	1,020
"*Salt Sand*"	18 "	1,038
Break	57 "	1,095
Sand	20 "	1,115
Slate, black	15 "	1,130
Middle stratum of "*Salt Sand*"	42 "	1,172
Limestone and slate	279 "	1,451
We should have another body of "*Salt Sand*" here to be regular with other wells of about a thickness of 60 feet, but found nothing but shells and lime. There was about 125 feet of lime, and found the "*Big Injun*" *Sand* 31 feet lower, there being an unusual break of 31 feet from the lime to the top of the "*Big Injun*" *Sand*, which we found at 1,451 feet.		
"*Big Injun*" *Sand*, (salt water at 1,518, more water at 1,575, streak of dark sand five feet thick at 1,685), sand white and hard, except where water was found	323 "	1,774
Limestone, hard, gray	61 "	1,835
(Limestone very hard, and drilled very slow, did not average over five feet per day. 1,600 feet salt water in hole. Cased 5 3-16-inch in hard limestone at 1,816).		
Limestone, gritty, very white	25 "	1,860
Sand, clear, white, (more water at 1,870)	45 "	1,905
Unrecorded	55 "	1,960
Slate	12 "	1,972
Sand, white	31 "	2,003
Shells and slate	342 "	2,345
Berea Sand, very black and mixed with slate, with a very hard		

cap on top, and a very hard shell in bottom; second bit showed a light coloring of oil in the bailer, very slight, but smelled very strong of fresh oil; a very slight showing of gas; both oil and gas disappeared by the time we finished; thickness	13 "	2,358
Bottom of hole	... "	2,362

This is the interpretation of the record as made by the superintendent of the McCalmont Company. An inspection of this record will reveal the fact that it agrees perfectly with the one at Spencer, the great salt water sand struck at 1,451 feet in the Harper well, being the same as that struck at 1,503 feet in the Spencer well and extending down to 1,830′, giving a thickness of 327 feet there as against 323 feet on the Harper farm. Then below each great salt water sand in both wells we find a hard limestone 75 to 86 feet thick, which corresponds to the character of the rock exactly that is found immediately on top of the "*Big Injun*" in the counties of Wirt, Ritchie, Calhoun, Gilmer, etc., north from Roane, while just *under* this *limestone* in the Harper well we find 143 feet of " white sand," with some slate inter-stratified, and this corresponds to the "*Big Injun*" *Sand*, below which at the proper interval (342′) is found the representative of the *Berea*, identified correctly by the McCalmont Company. Hence, taking all the facts into consideration, the 323 feet of sand struck at 1,451 feet in the Harper well should be called the basal member of the "*Salt Sand*" instead of "*Big Injun*," and the several sand rocks called "*Salt Sand*" above are the sands of the *Lower Coal Measures*, the *Allegheny* or *Kanawha river series.*

Nearly 40 miles east from the Harper well in Roane, or rather about 10° south of east, and a mile and a half below Sutton, Braxton county, the South Penn Oil Company has drilled a deep well on the Haymond

farm. The boring begins well down in the *Mahoning* or *Dunkard oil sand series* (which is there 250 feet thick), and not less than 600 feet below the horizon of the *Pittsburg coal.* The record of this well reads as follows:

Haymond Well No. 1.

On the Haymond farm, one mile and a half below Sutton, Braxton county, W. Va., near Elk river. Authority, South Penn Oil Co.

		Feet.
Conductor	50 to	50
Slate, blue	30 "	80
Sand, white, (*Lower Mahoning*)	80 "	160
Coal, (*Upper Freeport*)	6 "	166
Sand, white (cased 10-inch)	230 "	396
Slate, black	50 "	446
Sand, gray	100 "	546
Slate, black	20 "	566
Limestone, brown	75 "	641
Slate, black	30 "	671
Sand, gray, salt water, (top of "*Salt Sand*")	50 "	721
Slate, black	75 "	796
Sand, gray	20 "	816
Limestone, white	50 "	866
Slate, black	40 "	906
Sand, gray	50 "	956
Slate, blue	60 "	1,016
Limestone, gray	55 "	1,071
Slate, blue	54 "	1,125
Sand, yellow (salt water)	25 "	1,150
Slate	40 "	1,190
Sand, gray and white (base of "*Salt Sand*")	210 "	1,400
Slate, white	30 "	1,430
Limestone	35 "	1,465
Red rock	15 "	1,480
Slate, black	10 "	1,490
Limestone, white, (Mountain)	50 "	1,540
Slate, white	20 "	1,560
Sand, little black oil, (top of "*Big Injun*")	15 "	1,575
Limestone, white and gray (cased 6⅝-inch at 1,590)	290 "	1,865
Slate, black	50 "	1,915
Slate and shells	360 "	2,275
Sand, white, little oil, (*Berea*)	5 "	2,280
Slate and shells to bottom	445 "	2,725

The identifications made by the writer in the above record are not doubtful and may be relied upon as correct. They reveal the continuation of the great south-eastward thickening of all the measures which the records of the Asylum and Harper wells in Roane county show have already begun in a very marked way there, so far as the beds of the *Pottsville*, or "*Salt Sand*" series are concerned. This thickening expands the "*Salt Sand*" *series* to 729 feet in the Haymond well, and swells the *Allegheny river coal series* to 511 feet. The total increase is shown by comparing the intervals from the base of the *Mahoning* (*Dunkard*) *sandstone* beds in each of the two wells down to the *Berea Grit*. In the Asylum well of Roane, the base of the *Mahoning* beds was found at 967 feet, and in the Haymond well at Braxton at only 160, while the *Berea horizon* was struck at 2400 feet in the former well and 2275 feet in the latter, thus giving an interval of 2400′—967′=1433 feet in Spencer, and 2275′—160′= 2115 feet at Sutton, between these two horizons, a difference due to *thickening* of the measures of 2115′— 1433=682 feet in the 40 miles of intervening distance.

The top of the "*Big Injun*" sand is clearly shown in the Haymond well at 1560 feet, and the 290 feet of *limestone* below is really a continuation of the "*Big Injun*" horizon.

The next deep boring to the south-west of which we have a record, is near the locality of the famous "Burning Spring," on the Great Kanawha, 9 miles above Charleston. In 1887 a Pittsburg syndicate acquired leases in a region where large gas wells had been found and used in salt making nearly 60 years before, with the object of piping gas to Charleston if found in sufficient quantity. The first test well was

located in the Cool Spring branch of Burning Spring hollow, and a record preserved by the drillers has been given me by Hon. W. S. Edwards, of Charleston. The well starts about 100 feet below the *Campbell's creek*, or *Lower Kittanning coal*, and reads as follows:

Edwards Well No. 1.

		Feet.
Conductor	53 to	53
Coal, trace	... ..	....
Sand, hard, white	100 "	153
Slate, gray	8 "	161
Sand, gray, strong smell of oil	40 "	201
Slate, dark	25 "	226
Sand, hard, white, (top of "*Salt Sand*")	174 "	400
Coal, splint?	6 "	406
Sand, hard, white, *salty*	200 "	606
Slate, white	10 "	616
Limestone, white (shale)	50 "	666
Slate, white	40 "	706
Sand, hard, white	125 "	831
Sand, hard, white, flinty, salt	130 "	961
Slate, black	2 "	963
Sand, hard, white	50 "	1,013
Sand, hard, blue, base of "*Salt Sand*"	50 "	1,063
Limestone, blue, "Greenbrier," or "Long Running Rock," gas in bottom	300 "	1,363
Red rock, sandy, shaly	50 "	1,413
Unrecorded	187 "	1,600
Sand, coarse, heavily charged with *light oil*	2 "	1,602
Slate, blue	250 "	1,852
Slate, black	75 "	1,927
Slate, blue, shading into dark blue	323 "	2,250
Slate, shelly, with puffs of gas in last 50 feet	100 "	2,350
Slate, blue	50 "	2,400
Sand, shelly, with slight increase of gas	50 "	2,450
Slate, blue, very soft	92 "	2,542

The "*Salt Sand*" or *Pottsville series* in this boring is 837 feet thick, and contains the salt water brines from which salt has long been manufactured in this valley. The *limestone* at 1063 feet, reported 300 feet thick is not all limestone, but in addition to the *Mountain limestone* horizon in its upper half, has streaks of sand

in the lower portion which represent the "*Big Injun*" horizon, and in these occur the gas deposits. It was the expectation of the gas company that fair supplies of natural gas would be found here where large wells were obtained in the '40's, but although several wells were drilled, none of them measured a million cubic feet in volume, the rock having been practically exhausted of its original supply.

The total absence of coarse sands in the column of rocks for 1,200 feet below the "*Big Injun*" shows that the *Venango Oil Sands* were not deposited as coarse rocks in this region, their places being occupied by fine grained shales and slates, incapable of holding oil or gas in paying quantity.

Several other wells have been drilled along the Great Kanawha river, between Charleston and its mouth, but no paying oil or gas wells have yet been discovered.

On the land of Mr. C. T. Beale, six miles below Point Pleasant, in Mason county, W. Va., and just opposite Gallipolis, Ohio, a deep well was drilled several years ago. It begins on the general level of the Ohio river bottoms about 50 feet above low water, 200 feet under the *Pittsburg coal* horizon, and the record preserved by the drillers reads as follows:

C. T. Beale Well No. 1.

On the farm of C. T. Beale, in Mason county, W. Va., opposite Gallipolis, Ohio. Authority, Drillers' log book.

			Feet.
Quick sand and gravel (cased 10-inch at 58 ft.)	58	to	58
Red rock, soft (cased 8¼ inch)	72	"	130
Sand, white	7	"	137
Slate and red rock	113	"	250
Sand and slate	10	"	260
Limestone	5	"	265

			Feet.
Slate	5	to	270
Coal	2	"	272
Slate	18	"	290
Sand, gray	10	"	300
Slate, and very soft red rock	50	"	350
Sand, gray	5	"	355
Slate	25	"	380
Sand, white, salt water *Mahoning* (*Dunkard*)	67	"	447
Slate	63	"	510
Coal	7	"	517
Sand, white, salt water	213	"	730
Slate	30	"	760
Salt water sand, *No. XII*	170	"	930
Slate (cased 6¼ inch at 960)	45	"	975
Limestone, Mountain	165	"	1,140
Slate	10	"	1,150
Sand, "*Big Injun*," (and hard beds below)	400	"	1,550
Slate	151	"	1,701
Sand,(*Berea Grit*)	29	"	1,730
Slate	200	"	1,930
Sand, with salt water (*Gordon* series)	30	"	1,960
Slate (cased 4⅞ inch at 1969)	140	"	2,100
Sand	40	"	2,140
Slate (little gas at 2840)	730	"	2,870
Uurecorded to bottom of well	72	"	2,942

The well must have stopped on the *Corniferous Limestone* or within a few feet of it. If reliance can be placed upon the record, the presence of two members of the *Venango group* of oil sands is shown at 1930 and 2100 feet.

Near Central City, below Huntington in Cabell county, a well was drilled by a local company for gas in 1897. The well is located about one-fourth mile south from the C. & O. Depot on the Hisey fork of Four Pole, and starts about 340 feet below the horizon of the *Pittsburg coal* which here caps the tops of the highest hills back from the immediate valley of the Ohio. The record was furnished by Judge T. H. Harvey, of Huntington, one of the members of the company which drilled the well, and it reads as follows :

Central City Well.

On Hisey Fork of Four Pole Creek, about one-fourth mile back of C. & O. Depot, Central City, W. Va. Authority, Judge T. H. Harvey.

		Feet.
Conductor (clay and quicksand)	26 to	26
Shale, sand and lime (10-inch casing 61 ft.)	94 "	120
Limestone (fresh water rose 90 ft.)	7 "	127
Slate, with veins of fire clay	98 "	225
Sand, fine, (*Upper Mahoning, Dunkard*)	25 "	250
Slate	50 "	300
Sand, gas, (*Lower Mahoning*)	30 "	330
Black slate (*Upper Freeport coal* horizon)	10 "	340
Sand, gray	60 "	400
Slate, black	10 "	410
Sand, gray	85 "	495
Slate, white and blue	25 "	520
Sand and limestone	20 "	540
Slate (cased 8-inch at 547)	20 "	560
Slate, black	175 "	735
Sand, gray	25 "	760
Slate, black, blue (coal 2 ft.)	105 "	865
Sand, gas, and strong flow of salt water	30 "	895
Sand, black	10 "	905
Slate, black	30 "	935
Limestone	5 "	940
Slate, black	30 "	970
Limestone, (*Mountain*, 6¼-inch casing 987)	150 "	1,120
Slate	28 "	1,148
Sand, dark gray ("*Big Injun*,") some salt water	177 "	1,325
Shales and slate, black	370 "	1,695
Limestone or hard sand	10 "	1,705
Slate, brown	25 "	1,730
Sand, *Berea* "salt and pepper," (oil and gas)	25 "	1,755
Slate, black	10 "	1,765
Sand, hard, gray	5 "	1,770
Limestone	5 "	1,775
Sand, gray	10 "	1,785
Limestone	3 "	1,788
Slate, black	2 "	1,790
Limestone, bastard	4 "	1,794
Shale, black	20 "	1,814
Sand, (fine, black, powdery)	97 "	1,911
Shales and slates, black, blue and white	574 "	2,485
Limestone, bastard (*gas*)	15 "	2,500
Shale	250 "	2,750
Sand, gray	10 "	2,760
Corniferous limestone, very hard	10 "	2,770

Here the only *sand* of any promise in the lower or *Venango series* is the *Berea* which gave a small flow of gas, and a "show of oil" at 1730 feet. This is the only well in the State that has been drilled to the *Corniferous Limestone*, the top of that stratum having been encountered at 2760 feet.

The *Berea Grit* of this well has furnished some small gas flows to the south up the Big Sandy river in the vicinity of Louisa, and other points beyond, towards Richardson, Kentucky, but none were of commercial importance.

Further up the Tug Fork of Big Sandy, however, in the vicinity of Warfield, a very marked anticlinal wave crosses the river, and large gas wells have been found near its crest, not in the *Berea*, but in the "*Big Injun Sand*" horizon above.

In 1893, a well was drilled on the West Virginia side of the Tug river, opposite Warfield, by Messrs. Guffey, Queen and Heard of Pittsburg. The drilling operations were under the superintendence of Mr. George H. Dimmock, a veteran oil operator, who preserved a very carefully kept record of the well, which reads as follows:

Burning Springs Well.

Drilled in 1893, opposite Warfield, Ky., in Mingo county, W. Va., by Guffey, Queen, and Heard. Authority, G. H. Dimmock.

Top of well about level with Warfield (Lower Kittanning) coal.

		Feet.
Conductor	26 to	26
Slate, light colored	46 "	72
Sandstone, white, hard	44 "	116
Coal, (*Clarion, Eagle*)	5 "	121
Slate, white and soft	80 "	201
Sandstone, white	18 "	219
Slate, black, soft	20 "	239

		Feet.
Sandstone, white, hard, top *Pottsville Conglomerate*	20 to	259
Slate, light colored, shelly	57 "	316
Slate, black and soft	50 "	366
Slate, white and shelly	75 "	441
Sandstone, white, hard, (a little salt water at 457'; show of black oil at 552'; gas at 500')	130 "	571
Slate, light colored	15 "	586
Sandstone, white, (salt water and gas at 620)	46 "	632
Slate, light colored (cased 6¼-inch at 645)	20 "	652
Sandstone, white (a little salt water and gas at 720)	112 "	764
Slate, shelly, base of *Pottsville Conglomerate*	55 "	819
Red rock, top *Mauch Chunk Red Shale*	30 "	849
Slate, light colored	5 "	854
Red rock	25 "	879
Slate, light colored	15 "	894
Sand, very hard	18 "	912
Red rock	10 "	922
Sandstone, white, hard	24 "	946
Red rock	4 "	950
Slate, light colored	22 "	972
Limestone	4 "	976
Slate	10 "	986
Slate, shelly	20 "	1,008
Sandstone, dark, and very hard (a little salt water at bottom)	30 "	1,038
Limestone, Mountain, and "*Big Injun*" (gas at 1098)	162 "	1,200
Slate, shelly (gas in sand shell at top and also in sand shell at 1315)	138 "	1,338

The "*Big Injun*" *sand* is here changed to limestone with streaks of sand which hold gas in large quantity, one of the largest wells in the country having been struck at this horizon on the Warfield side of Tug river in 1882.

Further south from this on the waters of Marrowbone creek, a deep well was drilled of which the following record was sent me by Mr. B. N. Hawes, of Cleveland, Ohio, one of the parties interested in the well :

Marrowbone Creek Well.

Record of a well drilled on Marrowbone Creek, in Mingo county, W. Va. Authority, B. N. Hawes, Cleveland, O.

		Feet.
Conductor (soil and clay)	25 to	25
Unrecorded	165 "	190
Light sand	40 "	230
Slate, blue	50 "	280
Sand, light (salt water, gas and oil in lower part)	320 "	600
Slate, blue	230 "	830
Mauch Chunk Red Shale: red rock 65; slate, blue 15; red rock 90; slate, white 25	195 "	1,025
Sand	40 "	1,065
Limestone, Mountain, and "*Big Injun*" in part	205 "	1,270
Red slate	30 "	1,300
Slate, dark blue, gas, strong flow ("*Big Injun*")	94 "	1,394
Limestone, blue	20 "	1,414
Slate, black and brown (gas)	236 "	1,650
Sand, brown, hard and gritty, with mixture of lime	2 "	1,652
Slate, black	173 "	1,825
Sand, gray, very gritty and hard	12 "	1,837
Slate, black	48 "	1,885
Sand, gray, gritty, hard (*oil show* at 1900 ft.)	30 "	1,915
Slate, dark blue	185 "	2,100
Slate, light blue (tough and mixed with lime)	15 "	2,115
Slate, blue to bottom of well	111 "	2,226

The sand with an "*oil show*" at 1900 feet in the Marrowbone well is one which belongs in the *Venango Group*, and is probably a member of the "*Gordon*" *series*.

Near Dingess Station, on the Norfolk and Western Railroad, Mingo county, a well was drilled by Guffey and Queen, of Pittsburg, Pa., a record of which was preserved by Messrs. Gibson & Giles, the contractors. The derrick floor is 16 feet above the *coal* (*Lower Kittanning*, or *Warfield vein*) which is extensively mined in the vicinity, and the rock succession is as follows:

Dingess Well.

Record of well drilled near Dingess Tunnel on the Norfolk & Western Railroad, Mingo county, W. Va. Authority, Gibson & Giles, contractors, Pittsburg, Pa.

		Feet.
Soil	3 to	3
Sand, white	13 "	16
Coal, (Dingess vein, Lower Kittanning)	4 "	20
Sand, white	15 "	35
Slate, black	10 "	45
Sand, white	46 "	91
Coal	1 "	92
Slate, sandy	78 "	170
Slate, black	80 "	250
Sand, white	10 "	260
Slate, white	65 "	325
Pottsville Conglomerate No. XII, "Salt Sand." — sand, white, top of Pottsville..130; slate, black..... 48; slate, white..... 41; sand, white.....473; slate, black..... 11; *coal*, one of the New River series..... 6; slate, black..... 4; sand, white, water.....308	..1,021 "	1,346
(Oil show at 755, salt water at 828 to 964).		
Slate, black (cased 4⅞-inch)	22 "	1,368
Limestone, gray	6 "	1,374
Red rock	4 "	1,378
Limestone, gray	2 "	1,380
Slate, white	4 "	1,384
Red rock	2 "	1,386
Slate, white, sandy	8 "	1,394
Slate, white	26 "	1,420
Limestone, gray, shelly, oil show	51 "	1,471
Limestone, white, hard, *Mountain*, and "*Big Injun*" in part	125 "	1,596
Sand, red, hard ("Big Injun") gas	94 "	1,690
Slate, white, sandy	64 "	1,754
Slate, white	50 "	1,804
Sand, gray and dark	66 "	1,870
Slate, white, shelly	50 "	1,920
Slate, white	180 "	2,100
Slate, white, shelly	26 "	2,126

On the Guyandotte river, and near the mouth of Hart's Creek, Lincoln county, the Guyandotte Land Association put down a deep well in 1891, and the following record of the same was preserved by the superintendent, Mr. J. C. Miller:

Hart's Creek Well.

Record of well drilled by the Guyandotte Land Association near the mouth of Hart's creek, Lincoln county, W. Va. Authority, J. C. Miller, Superintendent.

		Feet.
Conductor	26 to	26
Slate, blue	20 "	46
Sandstone, white	80 "	126
Coal	9 "	135
Sandstone, white	89 "	224
Sandstone, gray	86 "	310
Slate, blue	107 "	417
Pottsville Conglomerate, No. XII, "Salt Sand": sandstone, white 20; " gray 80; " black 13; " white 290; slate, blue 20; sand, black 4; sand, gray 18; slate, blue 6; sand, yellow and flinty 38; slate, black 6; slate, blue 39; "Salt Sand," water 182	716 "	1,133
Shale, blue	18 "	1,151
Red rock (shale and sand)	20 "	1,171
Sand	42 "	1,213
Limestone, Mountain and "*Big Injun*"	160 "	1,373
Streak of gray sandstone, ("*Big Injun*"), big flow of gas	2 "	1,375
Limestone	75 "	1,450
Red rock	80 "	1,530
Slate, blue	180 "	1,710
Sandstone, gray	90 "	1,800
Slate and shells	12 "	1,812
Sandstone, gray, strong smell of oil (Berea)	15 "	1,827
Slate, blue	20 "	1,847
Sandstone, gray	10 "	1,857
Slate, blue	168 "	2,025
Sand, black (*show of oil*)	15 "	2,040
Slate, black and blue	460 "	2,500
Slate, blue	675 "	3,175
Sand, gray	8 "	3,183
Slate, black, soft, to bottom	77 "	3,260

The sand with "show of oil" at 2,025 feet is in the "*Gordon*" series, while that at 1,812 feet appears to be a representative of the *Berea*.

It will be observed that all of these well records, reveal a greatly thickened *Pottsville (No. XII) Conglomerate*, or *"Salt Sand" series* of the drillers when we go any considerable distance south from the Ohio river, and the *thickening* continues in that direction until the group swells to 1,400 feet where it all gets above water level on New River, near Sewell, Fayette county, while in southern McDowell the *"Salt Sand" series* is probably not less than 2,000 feet thick and holds the great Pocahontas coal bed, 300 feet above its base.

Returning now to the Ohio river region we shall pass northward and give a series of records showing the structure of the rocks along a line considerably west of the territory already covered.

Near the upper end of Mason county on the Ohio river, in the vicinity of Letart Falls, a well was bored in 1897 by the Sterling Oil Company, of which the following record was sent me by Mr. Daniel P. Gist, of Letart:

Sterling Oil Company's Well No. 10.

Near Letart, in Cologne District, Mason county, W. Va. Authority, Daniel P. Gist.

		Feet.
Drift	20 to	20
Sand	20 "	40
Red rock	60 "	100
White and red shales, soft	85 "	185
Sand, white	5 "	190
Red rock	115 "	305
Sand, white	8 "	313
Slate, dark	17 "	330
Trace of *coal (Pittsburg)*	10 "	340
Shale, light, sandy	25 "	365
Shale, light	40 "	405
Shale, black	20 "	425
Red rock	191 "	616
Slate, gray	39 "	655

			Feet
Red rock	35	to	690
Sand, hard, black	12	"	702
Slate, flinty	20	"	722
Sand, gray	3	"	725
Sand, soft, white	15	"	740
Shale, blue	15	"	755
Sand, white (*Mahoning*)	50	"	805
Shale, blue	10	"	815
Shale, brown and blue	25	"	840
Sand, soft, white	85	"	925
Shale, blue	20	"	945
Sand, white	50	"	995
Shale, blue	30	"	1,025
Sand, blue	15	"	1,040
Limestone	20	"	1,060
Sand, gray	37	"	1,097
Slate, gray	8	"	1,105
Slate, black and gray	30	"	1,135
Sand, white	35	"	1,170
Shale, blue	45	"	1,215
Shale, black	40	"	1,255
Shale, gray	30	"	1,285
Sand, soft, gray	20	"	1,305
Shale, black and blue	145	"	1,450
Shale, sandy	5	"	1,455
Slate, black	15	"	1,470
Sand, white, gas, (base of "*Salt Sand*")	60	"	1,530
Limestone, (*Mountain*)	60	"	1,590
Hard sand and gray slate	4	"	1,594
Limestone	10	"	1,604
Gray sand and limestone	24	"	1,628
Slate, black	4	"	1,632
Sand	10	"	1,642
Shale, blue, sandy	21	"	1,663
Slate, black	4	"	1,667
Sand, with salt water	12	"	1,679
Shale, blue, sandy	15	"	1,694
Sand, gray, with salt water, ("*Big Injun*")	159	"	1,853
Slate, blue	258	"	2,111
Slate, black	13	"	2,124
Sand, gray, with salt water, (*Berea*), to bottom	15	"	2,139

Letart Falls in the Ohio river is made by the emergence of a coarse, massive sandstone, the base of which is found at 250 to 275 feet above the *Pittsburg coal*, and

which may represent either the *Waynesburg* or *Uniontown sandstone* of the Monongahela river coal series; hence the coal reported in the Letart boring at 330 feet would represent the Pittsburg (Pomeroy) bed, and thus the record gives measurements between important strata. The *"Big Injun" sand* should probably begin at 1,590, but the main body of it appears from the record to come in at 1,694 feet.

Farther up the Ohio river, and 10 miles east from Letart, a well was drilled by Parkersburg parties, one-half mile below Ravenswood, in Jackson county. It begins on the Ohio river bottom near the junction of the Ohio River Railroad with the Ravenswood and Spencer Branch, and the record furnished by Mr. William Cale, the contractor, reads as follows:

Ravenswood Well.

Near Ravenswood, Jackson county, W. Va. Authority, William Cale.

		Feet.
Drift (river terrace trash)	65 to	65
Limestone and sand	80 "	145
Red rock	10 "	155
Shale, blue	8 "	163
Limestone with sand	15 "	178
Shale, blue	4 "	182
Shale, red	8 "	190
Limestone	20 "	210
Shale, blue	20 "	230
Limestone	26 "	256
Shale, red	12 "	268
Sand	4 "	272
Shale, blue	16 "	288
Sand, water	53 "	341
Coal	5 "	346
Shale, red and blue	12 "	358
Shale, gray	4 "	362
Sand, water and "oil show"	16 "	378
Shale, black	12 "	390
Shale, white	20 "	410
Sand, white	44 "	454

		Feet.
Rock, red	20 to	474
Shale, blue	53 "	527
Sand, water	5 "	532
Shale	22 "	554
Red rock	26 "	580
Shale, blue	52 "	632
Limestone	5 "	637
Shale	25 "	662
Sand (water)	38 "	700
Shale	10 "	710
Sand	30 "	740
Shale	10 "	750
Shale, black	30 "	780
Sand	53 "	833
Shale	32 "	865
Sand	20 "	885
Shale, black	5 "	890
Sand	70 "	960
Shale	20 "	980
Shale, black	10 "	990
Shale, blue	10 "	1,000
Sand	40 "	1,040
Slate, black	15 "	1,055
Shale, blue	25 "	1,080
Sand, water	20 "	1,100
Slate, black	40 "	1,140
Shale, blue	20 "	1,160
Limestone	15 "	1,175
Sand	47 "	1,222
Shale, black	33 "	1,255
Sand	85 "	1,340
Shale	42 "	1,382
Limestone and sand	38 "	1,420
Shale, black	12 "	1,432
Limestone	68 "	1,500
Limestone and sand	50 "	1,550
Slate	160 "	1,710
Sand ("*Big Injun*,") with water and oil, gas in bottom (cased 4⅞-inch at 1730′)	22 "	1,732
Slate	5 "	1,737
Sand ("*Big Injun*")	120 "	1,857
Shelly sand and gray shale	345 "	2,202
Shale, mixed with pebbly sand, (*Berea*,) gas and some oil	30 "	2,232

This succession of the rocks is somewhat puzzling, but as the well starts near the horizon of the *Wash-*

ington coal, there can be little doubt that the sand with water and some oil, struck at 1710 feet, is the top of the "*Big Injun*" or "*Keener*" division of that formation, while the sand at 2202 feet comes at the right interval below for the *Berea* horizon.

About 28 miles north from Ravenswood, the Camden Consolidated Oil Company of Parkersburg, drilled a well on the grounds of its refineries, one mile above the mouth of the Little Kanawha river, and the following record of the well was sent me by Mr. Cole, Superintendent of the Camden Consolidated Oil Co., soon after its completion :

Camden Consolidated Oil Company's Well at Parkersburg.

Record of well drilled by Camden Consolidated Oil Company, near Parkersburg, W. Va. Authority, Mr. Cole, Superintendent C. C. O. Co.

		Feet.
Loam, clay and quicksand	70 to	70
Sand, gray	15 "	85
Slate, soft, reddish blue	45 "	130
Sand, gray	15 "	145
Slate, soft, red and blue	85 "	230
Sand, gray (some fresh water)	10 "	240
Slate, red and gray	64 "	304
Sand, gray	31 "	335
Slate and soapstone, red, blue and gray, soft and irregular, (cased 5⅝-inch)	415 "	750
Slate, gray	70 "	820
Sand, hard, some salt water (*Mahoning*, *Dunkard*)	105 "	925
Slate, gray and black (trace of gas)	170 "	1,095
Bituminous coal, (*Lower Kittanning*)	7 "	1,102
Slate, gray	208 "	1,310
Sand, hard, white ("*Salt Sand*")	50 "	1,360
Slate, black	25 "	1,385
Sand, hard, gray ("*Salt Sand*")	50 "	1,435
Slate, gray	35 "	1,470
Slate and sand	30 "	1,500
Sand, white ("*Big Injun*") (strong gas and salt water, cased)	120 "	1,620
Slate, gray	280 "	1,900
Slate, black (odor of oil and gas)	45 "	1,945
Berea Oil Sand (slight trace of oil and gas)	2 "	1,947
Slate, gray	88 "	2,035

This well starts at about the same horizon in the rocks as the well at Ravenswood, and hence exhibits a thinning away of 150 feet in the measures between the "*Berea Grit*" and the surface.

Near Marietta, on the Ohio side of the river, 10 miles north from Parkersburg, we find the succession of the measures, in the well of the Marietta Gas Company, No. 2, Cherry farm, as given by Dr. Orton, the State Geologist, in Vol. VII, Ohio Geological Survey, pages 399-400, through the Berea. It is continued on below that horizon by the record of the Rake well in the same vicinity, as follows:

Marietta Gas Company's Well No. 2, on Cherry Farm, Combined with Record of the Rake Well.

		Feet.
Mud and clay	20 to	20
Gravel	4 "	24
Red mud	6 "	30
Limestone	20 "	50
Red sand	15 "	65
Slate	85 "	150
Red sand	20 "	170
Red rock	95 "	265
White sand	35 "	300
Red rock	100 "	400
White slate	20 "	420
Red rock and slate	150 "	570
Red sand	30 "	600
Red mud	10 "	610
Sand, gray	10 "	620
Slate, black	20 "	640
Sand, white	30 "	670
Slate	15 "	685
Sand	80 "	765
Slate	105 "	870
Sand	30 "	900
Slate	5 "	905
Sand, blue	15 "	920
Coal	5 "	925
Slate	25 "	950
Sand, black and blue	70 "	1,020

		Feet.
Slate	55 to	1,075
Sand	75 "	1,150
"Salt Sand"	235 "	1,385
Sand, dark gray	20 "	1,405
Slate and shale (Cuyahoga)	295 "	1,700
Shale, black (Berea shale)	55 "	1,755
Sand (Berea Grit, Macksburg)	5 "	1,760
(Continued from here by log of Rake well).		
Light slate and shells	38 "	1,788
Shale, blue, hard sand at bottom	226 "	2,014
Sand, soft, brown	9 "	2,023
Slate and shells	94 "	2,117
Slate	15 "	2,133
Slate and shells	22 "	2,155
Sand, brown	5 "	2,160
Sand and slate	5 "	2,165
Sand, brown	5 "	2,170
Slate, light	20 "	2,190
Slate and sand	15 "	2,205
Slate	10 "	2,215
Slate and sand	28 "	2,243
Slate, light	7 "	2,250
Slate	5 "	2,255
Slate and sand	8 "	2,263
Slate	7 "	2,270
Slate, light	15 "	2,285
Slate, dark	27 "	2,312
Slate, light	48 "	2,360
Slate, dark	40 "	2,400
Slate, light	80 "	2,480
Slate and sand	11 "	2,491
Slate	69 "	2,560
Slate and sand	10 "	2,570
Slate	115 "	2,685
Slate, soft	55 "	2,740
Slate	55 "	2,795
Slate and shells	10 "	2,805
Slate	115 "	2,920
Black slate to bottom	95 "	3,015

The 30 feet of "white sand" in this record at 640 feet appears to correspond with the top of the sand struck at 820 feet in the Parkersburg well, and the 235 feet of "Salt Sand" in the Marietta record includes the

"*Big Injun*" *sand* as well as a portion of the "*Salt Sand*" proper above.

Dr. Orton reports that no oil was found in any of the 1255 feet of measures penetrated below the *Berea* or *Macksburg sand* at Marietta, though Mr. Dye states that he found a *show of oil* on the W. Va. side of the Ohio opposite Marietta, 300 feet *under* the *Berea*. This would put the sand in question well down to the bottom of the *Venango series*.

An important oil pool has recently been discovered along the Ohio river on both sides of the same, 4 miles below Marietta, and Williamstown. The wells obtain the oil in what the drillers term the *First Cow Run Sand*, and it lies about 600 feet below the Ohio river.

The following record of No. 4 Moore, on the Ohio side of the river, sent me by Mr. F. E. Boden of Parkersburg, Vice President of the North American Oil Co., gives the succession of the different sands:

Moore Well No. 4.

Drilled by Clark and Sperry, four miles below Marietta.

		Feet.
Unrecorded	565 to	565
First Cow Run Sand	23 "	588
Unrecorded	157 "	745
Sand, some gas	100 "	845
Unrecorded	90 "	935
Second Cow Run Sand, strong gas	15 "	950
Unrecorded	92 "	1,042
"Macksburg 800-foot" Sand, some oil	61 "	1,103
Unrecorded	282 "	1,385
"*Big Injun*" *Sand* (water at 1400′, filled up full at 1440 ft., the bottom)	55 "	1,440

This is the succession as named by the drillers in the Boaz and Briscoe pools. The well begins about 50 feet below the level of the *Washington coal*, and hence the

sand called the *First Cow Run* here, is not the *Dunkard or Mahoning*, which would appear to be identical with the thick sand struck at 745 feet in the Moore No. 4, (820 in the Parkersburg well,) and which is usually termed the *Cow Run sand* by the drillers. The *Second Cow Run sand* of this well would appear to belong at the horizon of the *Freeport sandstone* of the Allegheny River Coal series, while the "*Macksburg 800-foot*" *sand* lies just above the *Pottsville* or "*Salt Sand*" series.

On the West Virginia side of the river here, 4 miles below Williamstown, in Wood county, the succession as given for the Aaron Pugh No. 7, by the Lockwood Oil Company, its owner, is as follows: the well begins on the "second bottom," 40 feet above the grade of the Ohio River Railroad (613′ above tide,) and 85 feet above the Ohio river low water:

Aaron Pugh Well No. 7.

	Feet.		
Drive pipe to bed rock through gravel and quicksand	107	to	107
Limestone	10	"	117
Red rock	55	"	172
Sand, white, coarse, (*Uniontown*)	35	"	207
Red and blue shales	468	"	675
First Cow Run Sand, with oil	41	"	716

This well produced 30 to 40 barrels an hour when first drilled in. The white sand at 172 feet appears to be identical with the massive cliff rock which overlies the coal mined 60 to 90 feet above river level at St. Mary's, Pleasants county, and is therefore possibly identical with the "*Carroll*" *shallow sand*, at Cairo.

In the No. 3, J. R. Uhl, near this, and only a few feet lower, the *Cow Run sand* was struck at 705 feet, but being thin and unproductive the well was drilled on below, and struck a producing sand at 1138 feet

which is possibly the top of the "*Macksburg 800-foot sand,*" since the "*Big Injun*" would be struck at about 1475 feet in this boring if continued on down.

Along the Ohio River Railroad right of way, the wells of Brown & Logan find the *Cow Run Sand* at 645 to 665 feet, starting at the level of the railroad track.

About 2½ miles up the river from the Brown and Logan wells, the Henderson Oil Company drilled some wells in 1895 on the land of the Henderson Bros., a mile and a half below Williamstown, and one-half mile back from the Ohio river. Mr. George L. Craig, one of the officers of this company gives the record of No. 3, Henderson Bros., as follows:

Henderson Bros. Well No. 3.

	Feet.
Unrecorded, (*First Cow Run Sand absent*)	710 to 710
Sand	.....
Unrecorded	100 " 810
Sand	.....
Unrecorded	190 " 1,000
Sand	.....
Unrecorded	414 " 1,414
Big Injun sand	90 " 1,504

The *First Cow Run Sand* horizon would come at about 600 feet in the above record, since as already shown by the Moore No. 4, on the Ohio side of the river, the top of the *First Cow Run Sand* comes 820 feet above the top of the "*Big Injun*" horizon, or 180 feet above the *Mahoning Sandstone* (*Dunkard*) which is so often confused with the *First Cow Run sand.* In the deep boring near Marietta, already given, the top of the *First Cow Run sand* would belong at about 460 feet and hence belongs in the 150-foot interval of "*red rock and slate,*" and this determination would seem to leave

but little doubt that the old first *Cow Run Sand*, which is the same as the *Briscoe sand*, cannot be the equivalent of the *Dunkard Sand* or *Upper Mahoning*, but must lie *above* that horizon, which begins at 820 feet in the Parkersburg well, and 640 feet in the Marietta deep well.

The relation of the producing sand in the *Athey "Cow Run Sand" pool*, two miles south from Williamstown, Wood county, is shown by the following record of the M. W. Athey well No. 1, drilled by the South Penn Oil Company in 1897:

M. W. Athey Well No. 1.

On the farm of M. W. Athey, about one mile and a half south of Williamstown, Wood county. Authority, South Penn Oil Co.

		Feet.
Conductor	14 to	14
Unrecorded	216 "	230
Sand, white	30 "	260
Unrecorded	260 "	520
Sand	10 "	530
Unrecorded	20 "	550
Coal (*Pittsburg?*)	8 "	558
Unrecorded	42 "	600
Red rock	100 "	700
Unrecorded	118 "	818
Cow Run Sand, dry, (broken sand)	22 "	840
Unrecorded	130 "	976
Sand	76 "	1,040
Shale and shells	389 "	1,435
Broken sand	22 "	1,457
Unrecorded	33 "	1,490
"*Keener*" *sand*	30 "	1,520
"*Big Injun*" *sand*, oil, gas and water at 1588	153 "	1,673
Bottom of well	"	1,673

It is quite probable that what is termed "*Keener*" sand in this record, as well as 50 to 60 feet of the underlying "*Big Injun*" of the driller, should be classed in the "*Salt Sand*" horizon. The coal reported at 550 feet is about where we should expect the *Pitts-*

burg bed in this region, if present, and it is, therefore, doubtfully referred to that stratum.

The *Cow Run Sand* was shelly and *dry* in this well, but in No. 3, not far away it was struck at 798 feet, and produced oil at 808, extending to 823 feet.

The *Ogdin, Hendershot, and Murphytown Berea sand oil pools*, which are all practically one, lie in Union and Clay Districts of Wood county.

The following record of the J. B. Hendershot well No. 1, drilled by the South Penn Oil Company, will give the rock succession in that region which is about 6 miles south from Waverly, and 10 miles from Williamstown. The record is as follows, according to the South Penn Oil Company:

J. B. Hendershot Well No. 1.

		Feet.
Unrecorded	20 to	20
Red rock	20 "	40
Limestone, gray	60 "	100
Red rock	20 "	120
Limestone, white	20 "	140
Red rock	60 "	200
Limestone, white	40 "	240
Sand	20 "	260
Red rock	30 "	290
White slate and Limestone	40 "	330
Limestone	30 "	360
Sand	80 "	440
Slate, white	60 "	500
Red rock	80 "	580
Limestone	20 "	600
Red rock	150 "	750
Sand	25 "	775
Red rock	60 "	835
Limestone and shells	100 "	935
White drilling	65 "	1,000
Red rock	40 "	1,040
Cow Run Sand	20 "	1,060

		Feet.
Slate, white	30 to	1,090
Limestone, black	20 "	1,110
Black cave	44 "	1,154
Slate, black	136 "	1,290
"Salt Sand," top	40 "	1,330
Slate, black	160 "	1,490
Sand	20 "	1,510
Slate	30 "	1,540
Cairo Sand	30 "	1,570
Slate, black	60 "	1,630
Sand (bottom of "Salt Sand")	20 "	1,650
Limestone, black	20 "	1,670
"*Big Injun*" *Sand*	200 "	1,870
Slate, black	5 "	1,875
Limestone	10 "	1,885
Slate	5 "	1,890
Limestone, hard	10 "	1,900
Slate and shells	100 "	2,000
Slate	20 "	2,020
Slate and shells	40 "	2,060
Slate, black	160 "	2,220
Shale, black	16 "	2,236
Berea Sand	11 "	2,247
Limestone, blue	14 "	2,261

Oil increased from top to bottom of *Berea* sand

The driller has probably placed the "*Cow Run*" *Sand too low* in this record, and the top of the "Salt Sand" *too high*, since what he has termed the "*Salt Sand*" is probably the "*Second Cow Run*," and it is also possible that the upper portion of the 200 feet which has been classed in the "*Big Injun*," should belong in the "*Salt Sand*" horizon, unless the 20 feet of "*black limestone*" represents the *Mountain limestone.*

The J. B. Hendershot No. 2, located near No. 1, but 50 feet lower on the hill, gives some data not shown in No. 1, and reads as follows, according to the South Penn Oil Company's log:

J. B. Hendershot Well No. 2.

		Feet.
Conductor	20 to	20
Clay, yellow	20 "	40
Red shale	40 "	80
White shale	20 "	100
Red shale	100 "	200
White shale	50 "	250
Red shale	100 "	350
White shale	100 "	450
Red shale	50 "	500
White shale	50 "	550
Sand, white	10 "	560
Shale, white	90 "	650
Shale, pink, cave	100 "	750
Shale, red	50 "	800
Shale, white	50 "	850
Sand, white	10 "	860
Shale, red	40 "	900
Sand, white	10 "	910
Shale, white	50 "	960
Sand, white	15 "	975
Shale, white	25 "	1,000
Limestone, black	10 "	1,010
Shale, white	40 "	1,050
Shale, white	30 "	1,080
"*Cow Run*" *Sand*	45 "	1,125
Shale, white	50 "	1,175
Sand, white	25 "	1,200
Shale, white	75 "	1,275
"*Salt Sand*"	125 "	1,400
Shale, black	50 "	1,450
Shale, white	50 "	1,500
Shale, black	100 "	1,600
Sand, gray, (base of "*Salt Sand*")	80 "	1,680
"*Big Injun*" *sand*	120 "	1,800
Slate and hard lime shells	370 "	2,170
Shale, black	12 "	2,182
Sand, *Berea Grit* (oil)	9 "	2,191
Slate, white, to bottom	17 "	2,208

Here is a good illustration as to the way the "*Cow Run*" horizon is passed up and down at the driller's whim, since in the No. 2 well, its name is given to a rock which lies 90 feet lower than the stratum which

was given the same name in well No. 1, while the real *First Cow Run Sand* horizon probably lies a considerable interval above both. It is also probable that the top of the "*Salt Sand*" has been placed too high in the record, and that the stratum in question should be called the "Second Cow Run Sand," while what is called the "*Cow Run*" is really the *Upper Mahoning sandstone* or *Dunkard oil sand* which is so often termed the "*Cow Run*" *sand*, by the drillers, but which we have just seen in the Marietta region, is not the equivalent of either the *First* or *Second* "*Cow Run*" *Sand*, but lies about midway between them.

About three miles south-west from the Hendershot farm, and in the Murphytown region, the No. 1 well on the J. D. Walker farm, begins about 770 feet above tide, or 150 feet higher than the Parkersburg well, and 200 feet below a white limestone which caps a great mass of deep *red shale* in the hills above. This record exhibits some features not shown in the Hendershot wells, and is as follows:

J. D. Walker Well No. 1

On the farm of J. D. Walker, near the center of the Hendershot Oil Field, in Wood county. Authority, South Penn Oil Co.

		Feet.
Conductor	20 to	20
Red rock	16 "	36
Sand	119 "	155
Red rock	5 "	160
Slate, white	5 "	165
Coal	5 "	170
Red rock	55 "	525
Slate, white	55 "	280
Sand (10-inch casing at 308 ft.)	50 "	330
Red rock	175 "	505
Sand	20 "	525
Slate, white	25 "	550
Red rock	30 "	580

		Feet.
Slate, white	20 to	600
Red rock	30 "	630
Sand	15 "	645
Slate, white	25 "	670
Red rock	72 "	742
Sand	53 "	795
Red rock	25 "	820
Slate, white	40 "	860
Red rock	40 "	900
Slate, black	55 "	955
Red rock	25 "	980
Slate, white (8¼-inch casing 1050 ft.)	161 "	1,141
Sand	49 "	1,190
Slate, black	99 "	1,289
Sand	21 "	1,310
"Salt Sand" (strong flow of water at 1370)	170 "	1,480
Cairo sand	20 "	1,500
"*Big Lime*"	90 "	1,590
"*Big Injun*" *sand*	222 "	1,812
Slate, black (6⅝-inch casing at 1822 ft.)	337 "	2,149
Berea Sand, (oil; increased to 2160 ft.)	11 "	2,160
Unrecorded to bottom of well	17 "	2,177

The *Berea* was struck in this well at a depth 200 feet greater than at Parkersburg, thus showing a dip of only 50 to 60 feet in the direction of Murphytown from Parkersburg, 8 miles distant.

A very deep well has been drilled in Wood county, on the land of Judge John J. Jackson, five miles northeast from Parkersburg, by the South Penn Oil Company, from whose log book the following record is reported :

Judge John J. Jackson Well No. 1.

		Feet.
Conductor	25 to	25
Red rock	25 "	50
Sand, gray	50 "	100
Slate, white	25 "	125
Sand, gray	25 "	150
Red rock	15 "	165
Limestone	10 "	175

		Feet.
Slate, white	25 to	200
Red rock	15 "	215
Sand, gray	15 "	230
Slate, white	10 "	240
Red rock	25 "	265
Sand, white	25 "	290
Red rock	100 "	390
Slate, white	10 "	400
Sand, white	5 "	405
Slate, white	15 "	420
Limestone	10 "	430
Sand, white	15 "	445
Red rock	20 "	465
Limestone	10 "	475
Slate, black	25 "	500
Red rock	30 "	530
Slate, black	20 "	550
Sand, white	25 "	575
Slate white	25 "	600
Red rock	105 "	705
Slate, white	50 "	755
Sand, white	20 "	775
Slate, white	10 "	785
Sand, white	15 "	800
Red rock	30 "	830
Slate, white	20 "	850
Sand, white	15 "	865
Slate, black	25 "	890
"*Cow Run*" *sand* (*Mahoning*), water at 915 feet	110 "	1,000
Slate, white	50 "	1,050
Sand, gray	30 "	1,080
Slate, white	37 "	1,117
Slate, black	30 "	1,147
Sand, white	120 "	1,267
Slate, white	30 "	1,297
Slate, black	60 "	1,357
"*Salt Sand*" (water at 1,390)	100 "	1,457
Limestone	15 "	1,472
Slate, white	15 "	1,487
"*Big Lime*"	18 "	1,505
"*Big Injun*" *Sand* — sand, white, water 1,525	140	
sand, black	10	
sand, white	40	
sand, black	15	
	205 "	1,710
Slate and shells	283 "	1,993
Slate, black	30 "	2,023
Shells (*Berea*), dark and poor. no oil or gas	52 "	2,075

	Feet.
Slate and shells	375 to 2,450
Shells (*Gordon*) and white slate, soft and smelled oily	566 " 3,016
Bottom	" 3,016

For comparison with all of these records from Wood county, and the Marietta region, the following record of a well near Macksburg, Noble county, Ohio, known as George Reis well No. 18 is here given on the authority of John Garber, of Parkersburg:

George Reis Well No. 18, at Macksburg, Ohio.

		Feet.
Conductor	10 to	10
Coal, Macksburg	5 "	15
Soapstone	8 "	23
Sandy shale	117 "	140
Limestone, blue	13 "	153
Slate, blue	10 "	163
Limestone, blue	12 "	175
Slate, blue	45 "	220
Red "cave" (red rock 10; blue slate 7; red slate 18)	35 "	255
Slate, blue	15 "	270
Slate, red	7 "	277
Slate, blue	38 "	315
Limestone, blue	28 "	343
Sand (*"140-Foot Sand," "First Cow Run"*)	35 "	378
Slate, blue	32 "	410
Slate, black	10 "	420
Slate, blue	5 "	425
Slate, red	27 "	452
Slate, blue (cased)	4 "	456
Limestone	14 "	470
Slate	72 "	542
Limestone (water)	12 "	554
Sand (*"300-foot" sand, Mahoning, Dunkard*)	78 "	632
Slate	53 "	685
Sand (*"500-foot" sand*)	17 "	702
Slate	39 "	741
Sand	9 "	750
Limestone	25 "	775
Sand, pebbly (*"800-foot" sand*)	51 "	826
Slate	79 "	905

		Feet.
"*Salt Sand*".....	sand, hard.....68 slate, black.....54 sandstone, hard, white.....68	.....190 to 1,095
Slate, dark.....		21 " 1,116
Sand, dark, pebbly ("*Salt Sand*" and "*Big Injun*").....214		" 1,330
Slate, light, black at bottom.....293		" 1,623
Slate, black.....		11 " 1,634
Shells and black slate.....		44 " 1,678
Macksburg (*Berea*) *oil rock*.....		17 " 1,695

The sand at 1,116 feet is the one which was always known as the "*Salt Sand*," by the Macksburg operators, but its upper half only, belongs in the West Virginia operators' "*Salt Sand*," while its lower half is the "*Big Injun*," the *Mountain limestone* usually separating them, having thinned away and permitted the two distinct formations to combine practically into one rock.

Whether the sand at 685 feet, or that at 775 represents the "*Second Cow Run*" is not known certainly, but more probably the latter.

We have dwelt longer upon Wood county than other regions because of its proximity to the fields of Ohio, and the importance of showing clearly the relations of the *sands* of the one state to that of the other.

Returning now to Ritchie county, on the great "oil break" anticlinal, just east from the Wood county line, we get the following record of a deep well drilled on the Mount farm (No. 16) according to Mr. J. F. Partridge, of Laurel Junction, Wood county, W. Va.:

Mount Farm Well No. 16.

		Feet.
Conductor.....	14 to	14
Shale.....	14 "	28
Sand.....	11 "	39
Coal.....	2 "	41
Soapstone.....	15 "	56

			Feet.
Sand, dark	12	to	68
Shale	62	"	130
Coal	3	"	133
Shale	59	"	192
Sand, gray	57	"	249
Shale	99	"	348
Sand, gray	28	"	376
Sand, dark, pebbly	10	"	386
Shale	9	"	395
Sand, gray	24	"	419
Shale	5	"	424
Sand, gray	50	"	474
Shale	5	"	479
Sand, pebbly (base of "*Salt Sand*")	6	"	485
Limestone, (*Mountain*)	44	"	529
Sand, white ("*Big Injun*")	121	"	650
Shale	368	"	1,018
Macksburg sand (*Berea*)	10	"	1,023
Shales and hard shells	1,610	"	2,638
"*Grit*," (sandy material)	19	"	2,657
Shales, soft, caving	140	"	2,797
Shales, caving badly	45	"	2,842
Shale, blue	11	"	2,853
Shale, dark, with pebbles	47	"	2,900
Shale, dark, to bottom	47	"	2,947

The *coal* bed at 39 feet is the one mined along the B. & O. R. R. between Petroleum and Volcano, and lying 150 feet below the top of the massive, grayish white sandstone series so often called "*Cow Run*" by the drillers and which was struck in the Parkersburg well at 820 feet. The top of the corresponding stratum would come about 110 feet above the floor of the derrick on the Mount farm.

The bottom of this well cannot be very far above the *Corniferous Limestone*, since the rocks were penetrated at least 3500 feet below the horizon of the *Pittsburg coal*.

For comparison with the upper portion of this deep well, we give here the record of well No. 1 on the West

Virginia oil tract, Steele run, a mile and a quarter north from Petroleum station on the B. & O. R. R. Authority, C. F. Pontius:

Record of Well No. 1, West Virginia Oil Tract.

		Feet.
Coal bed 10 feet above derrick floor.		
Unrecorded	358 to	358
Shale	40 "	398
Sand (second oil rock)	33 "	431
Sand, gray	14 "	445
Limestone (*Mountain*)	16 "	461
"*Big Injun*" — sand, yellow 24; sand, white 34; sand, white, hard 40; shale 14; sand, gray ("Squaw") 34	146 "	607
Shales, dark	371 "	978
Berea sand, oil	10 "	988
Shales and shells to bottom	812 "	1,800

The coal 10 feet above the derrick floor is the one mined along the B. & O. R. R., one mile west from Petroleum, and the same as that struck at 39 feet in the Mount farm deep well.

The *Mountain limestone* is only 16 feet thick as against 44 feet at the Mount farm, but it and the "*Big Injun*" (16′ + 146′) = 162′, are together of practically the same thickness as on the Mount farm, (44′ + 121′) = 165 feet.

The sand at 398 feet is the *Cairo oil sand*, seven miles east from Petroleum.

The Berea or *Macksburg sand* which is so clearly defined in this well, is still producing oil, though drilled in 1886.

The Cairo oil field of Ritchie county, was first opened in October, 1890, by Messrs. Boden and Aiken, of Parkersburg. This first well which is now owned by

the Cairo Oil Company, is situated one-fourth of a mile south from the railroad station, and the record reads as follows, according to Boden & Aiken, the original owners.

Boden and Aiken Well No. 1.

		Feet.
Conductor	16 to	16
Limestone	12 "	28
Shale	12 "	40
Sand	15 "	55
Shale	30 "	85
Shale, light	45 "	130
Sand; sharp, white (*Carroll oil sand*)	43 "	173
Shale, (7⅝ casing, 175 ft.)	36 "	209
Coal	1 "	210
Sand, dark	11 "	221
Shale, light	12 "	233
Slate, red	16 "	249
Shale, light	12 "	261
Slate, red	10 "	271
Sand, dark gray	7 "	278
Slate	11 "	289
Slate, red	19 "	308
Shale, soft, blue	20 "	328
Shale, red	9 "	337
Limestone	10 "	347
Shale, light	52 "	399
Red rock	10 "	409
Shale, light	7 "	416
Red rock	2 "	418
Shale, light	5 "	423
Red rock	44 "	467
Shale, light	16 "	483
Sand	25 "	508
Red rock	15 "	523
Shale, light	11 "	534
Red rock	9 "	543
Shale, light	30 "	573
Red rock	5 "	578
Sand	55 "	633
Red rock	26 "	659
Shale, light	19 "	678
Red rock	20 "	698

			Feet.
Sand (5⅝-inch casing, 725 ft.)	78	to	776
Shale, light	12	"	788
Shale, dark	25	"	813
Shale, red, sandy	13	"	826
Shale, light	92	"	918
Sand	5	"	923
Shale, black	10	"	933
Shale, light	135	"	1,068
Sand, light	64	"	1,132
Shale, light	26	"	1.158
Shale, black	20	"	1,178
Sand, *gas*	90	"	1,268
Shale, gray	94	"	1,362
Sand	10	"	1,372
Shale	70	"	1,442
Sand, (*Cairo Oil Sand*)	57	"	1,499
Mountain Limestone: shale 16; *limestone* 50; sand 12; sand and limestone 12	90	"	1,589
Sand "*Big Injun*" (oil, 1,678 ft.)	97	"	1,686
Unrecorded to bottom	374	"	2,060

The *Cairo sand*, as will be seen from the record, is the basal portion of the *Pottsville* (*No. XII*) *series*, and, therefore, most probably identical with the *Maxton sand* of Tyler county.

Some oil was also obtained in the "*Big Injun*" *Sand* at 1,678 feet.

Another record near Cairo, was kept for the Survey with much care by Mr. Wm. A. Clark, of the Clark Oil Company. The well was drilled in 1898, and is Lee No. 6, situated on the summit of a hill, 250 feet above Hughes river, and one-half mile north-west from the town of Cairo. The record runs as follows:

Lee Well No. 6, Near Cairo.

			Feet.
Unrecorded	35	to	35
Coal, Washington	2	"	37
Unrecorded	213	"	250

			Feet.
Carroll oil sand	40	to	290
Red beds (10-inch casing 330 ft.)	60	"	350
Lime "shells"	95	"	445
Red rock	35	"	480
White slate and "lime shells"	160	"	640
"Big" red bed	100	"	740
Black slate and lime	115	"	855
Unrecorded	20	"	875
"Pink cave" (8¼-inch casing)	10	"	885
Unrecorded to bottom of a sand	25	"	910
Black slate	50	"	960
Sand, *Dunkard*	40	"	1,000
Slate, black	30	"	1,030
Red rock	15	"	1,045
Sandstone, very hard	10	"	1,055
Limestone	15	"	1,070
White slate and "shells"	50	"	1,120
Sandstone	25	"	1,145
Black slate and "lime shells"	47	"	1,192
Sand	15	"	1,207
Slate, black	33	"	1,240
Sand	35	"	1,275
Dark *Coaly* shales ("cave"), cased at 1,310, 6¼-inch	45	"	1,320
"*Casing sand*"	40	"	1,360
Shale, black	15	"	1,375
Sand, pebbly (top "Salt Sand")	113	"	1,488
Slate, black	10	"	1,498
Shale, gray	10	"	1,508
Slate	22	"	1,530
"*Gas Sand*"	20	"	1,550
Slate and shells	20	"	1,570
Shale, gray	20	"	1,590
Sand	10	"	1,600
Shale, black	5	"	1,605
Sandy beds, limy	5	"	1,610
Sand, white	15	"	1,625
Black slate and lime	20	"	1,635
"*Salt Sand*," *Cairo* and *Maxton oil sand;* broken for 15 feet, very hard and dark, then whiter at 1660 ft., softer at 1680 ft., showing oil at 1682½ ft.; through 'pay' at 1687; sand harder with bluish cast at 1690, and making 3 barrels of salt water per hour; soft sand to bottom; total thickness	55	"	1,700
"*Big Lime*," (*Mountain Limestone*) to bottom of well	35	"	1,735

The top of the "*Big Injun*" *Sand* would be found at about 1,790 feet in this well, since the *Mountain Lime-*

stone is 80-90 feet thick in the Cairo region, hence the base of the *Carroll Sand* comes here 1,500 feet above the "*Big Injun*" oil sand, and as the *Berea Grit* lies 495 feet below the top of the "*Big Injun*" *sand* as shown by the record of Hatfield No. 2, near Cairo, then this *Carroll sand* would be 1,995 feet above the *Berea Grit* horizon at Cairo, thus showing a thickening of 200 feet between St. Mary's and Cairo, since the Tan Lot well at St. Mary's, Pleasants county, 15 miles north of Cairo, found the *Berea* at only 1,790 feet below the base of the massive sandstone and *Macksburg coal* which crop out there, and the St. Mary's *sand rock* appears to be identical with the *Carroll sand* of this record.

About four miles north-east from Cairo, a deep well was drilled on the Chancellor tract, by Ira DeWitt, of Pittsburg, who reports the following succession of the strata:

Chancellor Tract Well No. 1.

Record of well No. 1 on the Chancellor Tract, Dilly farm, Grant district, Ritchie county, W. Va., four miles north-east of Cairo. Authority, Ira DeWitt.

		Feet.
Conductor	8 to	8
Sand, blue	30 "	38
Red slate	20 "	58
Limy slate	40 "	98
Unrecorded	10 "	108
Slate (cased 10-inch at 120)	55 "	163
Sandstone, red, and white shales	82 "	245
Slate, gray	31 "	276
Sand, blue	12 "	288
Sand, white	20 "	308
Slate	75 "	383
Pittsburg coal?	3 "	386
Slate, gray	14 "	400
Slate, dark	60 "	460
Slate, red	15 "	475
Slate, dark	25 "	500

		Feet.
Sand, gray	15 to	515
Slate, red	72 "	587
Slate, light	33 "	620
Slate, red	37 "	657
Slate, brown	47 "	704
Red (cave)	43 "	747
Shells	5 "	752
Blue (cave)	22 "	774
Coal	6 "	780
Blue (cave)	16 "	796
Limestone	10 "	806
Slate, white	12 "	818
Slate, dark	32 "	850
Sand	10 "	860
Slate, brown (show of coal at 870 ft.)	10 "	870
Slate, light	5 "	875
Sand	5 "	880
Slate	10 "	890
Slate, white (cased 6¼-inch at 897)	10 "	900
Sand	5 "	905
Slate	25 "	930
Sand	5 "	935
Limestone(?), show of coal at bottom	65 "	1,000
Sand, dark	15 "	1,015
Slate	17 "	1,032
Limestone	21 "	1,053
Slate	39 "	1,092
Sand	10 "	1,102
Slate	16 "	1,118
Sand	19 "	1,137
Slate	19 "	1,156
Limestone	6 "	1,162
Sand	34 "	1,196
Slate	44 "	1,240
Sand, *gas*	61 "	1,301
Slate, dark	19 "	1,320
Sand, slaty	60 "	1,380
Slate	35 "	1,415
Sand, hard	10 "	1,425
Sand and slate	25 "	1,450
Sand, light, ("*Salt*"), gas at 1,500, (*Cairo, Maxton*)	70 "	1,520
Slate, black	20 "	1,540
Sand, dark	15 "	1,555
Mountain Limestone { limestone ..... 5 / sand ..... 10 / limestone, gray ..... 68 }	83 "	1,638

			Feet.
"*Big Injun Sand*"	sand	14	
	sand, blue	19	
	slate, black	12	140 to 1,778
	sand	88	
	sand, brown	7	
Slate, dark			222 " 2,000
Sand shells			50 " 2,050
Slate, dark			92 " 2,142
Gantz sand (*Berea*) at			2,142

I have marked as doubtful the identification of the *Pittsburg coal* in this record, but the evidence preponderates in favor of its correctness, since this would put it 1252 feet above the "*Big Injun*" *Sand*, while at the nearest localities in Tyler and Doddridge this interval is 1280 to 1300 feet; then, too, it makes an interval of 493 feet between the *Washington coal* of the Lee No. 6 record, and the *Pittsburg* of the Chancellor tract, by referring both to the top of the *Mountain Limestone* which is about the interval we would expect in this region, and in addition, the *bad "red cave"* of the drillers ends at 361 feet below the coal in question which is the usual interval below the *Pittsburg bed*, so that taking all the evidence together, we may consider the supposed identity very strongly confirmed. As a corollary to this we find the base of the *Carroll oil sand* (Cairo "shallow sand,") at 238 feet above the *Pittsburg coal*, and hence at the horizon of the *Uniontown*, or *St. Mary's sandstone*, which overlies the *Macksburg coal*.

The record also gives an interval of 1756 feet between the *Pittsburg coal* and the *Gantz sand horizon*, and definitely identifies the latter with the *Macksburg sand*, or what the drillers universally term the *Berea*, whether the *Macksburg sand* be identical with the *Berea Grit* or otherwise.

The Cairo oil field extends south from the town roughly parallel to the line of the Burning Springs-Eureka anticlinal, and about 7 miles distant from it, crossing the South Fork of Hughes river one mile above the mouth of McFarlan run, passing in its course the famous Ritchie mine of Grahamite.

Soon after oil was found at Cairo, M. Murphy, Fred Hayes and others concluded to drill a well near the fissure which holds the Grahamite, and a well was located about 300 feet distant from it, and drilled to the "*Big Injun*" *Sand.* The well begins 140 feet under the *Washington coal*, and the record preserved by the contractor reads as follows:

Ritchie Mines Well.

On McFarlan Run, Ritchie county, W. Va., 8 miles south of Cairo.

		Feet.
Unrecorded (cased 7⅝-inch at 247 ft.)	600 to	600
Slate, black	57 "	657
Red rock	15 "	672
Black slate and shale	28 "	700
Red rock	40 "	740
Limestone and shells	10 "	750
Red rock	10 "	760
Shale, light red	5 "	765
Red rock	20 "	785
Blue sand and limestone	15 "	800
Sand, gray, with *show of oil* (*Dunkard*)	30 "	830
Hard shell of flint and limestone	10 "	840
Sand and slate (cased 6¼-inch)	30 "	870
Slate	10 "	880
Sand with limestone	10 "	890
Slate, dark	55 "	945
Sand, gray, with shell to bottom	15 "	960
Slate, light	10 "	970
Sand, gray	10 "	980
Coal	5 "	985
Slate, black	5 "	990
Sand, gray	15 "	1,005
Slate and sand	10 "	1,015

		Feet.
Slate	5 to	1,020
Sand, light gray and soft	25 "	1,045
Slate, dark	5 "	1,050
Sand	20 "	1,070
Slate	20 "	1,090
Sand, white (gas enough to run boiler) "*Gas sand*"	15 "	1,105
Unrecorded	37 "	1,142
Sand, white	33 "	1,175
Break of slate	5 "	1,180
Sand, white	30 "	1,210
Slate	150 "	1,360
Sand, gray and coarse	20 "	1,380
Slate	8 "	1,388
Sand, gray and coarse	12 "	1,400
Shell	2 "	1,402
Slate, black	88 "	1,490
"*Salt Sand.*" sand, white (gas) 25; sand, (oil at 1530′) 15; sand 26; slate 4; sand 23	93 "	1,583
Limestone (*Mountain*)	67 "	1,650
Top of "*Big Injun*" *sand*	... ..	1,652

The *Cairo, Maxton* or "*Salt Sand*" of the drillers is the oil sand here, and although within 300 feet of the fissure 1–5 feet wide filled with grahamite, a mineral of coal-like appearance (and doubtless originating from the oxidation of the products of petroleum which filled the fissure after it had penetrated the "*Salt Sand*" *oil* horizon at 1,530 feet), nevertheless the well yielded about a barrel of oil daily, while others drilled 700 to 800 feet distant from the fissure, produced 10 to 50 barrels daily, thus showing that in this "*Salt Sand*" at least, the limit of *drainage* is not very far. Mr. W. K. Jacobs, the Superintendent of the Sill and Cairo Oil Companies operating in this region, informs me that wells drilled close to the fissure find good sand, but that it acts like territory that has been *drained* of its oil, and such it really is, since the *grahamite fissure*, nearly a mile long and from one to five feet wide at

the surface, and extending down over 1,500 feet, below the valley, + several hundred feet to the tops of the hills and including that lost by general erosion, would certainly be the equivalent of many hundred thousand barrels of petroleum, even had none been lost in the process of filling the fissure, which is of course, inconceivable to any one acquainted with oil well phenomena.

The *Cairo oil belt* has now been traced to and beyond the South Fork of Hughes river, the Sill Oil Company having completed a fair well, No. 3, on Fred Lemon, one mile above McFarlan, during the latter part of 1898. In this well which begins about 110 feet above Hughes river, and 100 feet below the *Washington coal*, the "*Gas Sand*" was struck at 1,386 feet, and the "*Salt Sand*" at 1,520 feet, with oil at 1,586, and the bottom or *Mountain Limestone* at 1,627, while the "*Big Injun*" would have been found at about 1,717, according to the measurements in the Doc. Lemon well near by. In the Fred Lemon well No. 3, Mr. Jacobs reports *17 feet of coal and coaly slate* at 1,225 feet, which would doubtless correspond to the *Lower Kittanning bed.* The shale (or fire clay possibly) in connection with this coal has a tendency to "cave," and hence the last string of casing is usually put through this stratum to the top of a sand a few feet under it which the drillers term the "casing sand."

The "*Gas sand*" of this region is probably the top member of the *Pottsville series*, since this would give those beds a thickness of 241 feet in the Lemon wells from the top of the "*Gas sand*" down to the bottom of the "*Salt*" or *Cairo oil sand.* The "*gas sand*" of the Ritchie Mine well is not the same as the one usually so designated on the *Cairo oil belt*, since the former lies

250 feet higher, and is probably equivalent to the *Freeport sandstone*, the "gas sand" of Marion and Monongalia county drillers.

The Whiskey Run Oil Pool lies about 9 miles northeast from Cairo, and 3½ miles from Ellenboro, near the headwaters of Bond creek in northern Ritchie county. The first well was drilled there early in the '90's by Ira DeWitt and the South Penn Oil Company, on the Hamilton farm. The well produced a little oil from the top of the *"Big Injun"* or *"Keener" sand* horizon at 1749 feet, and such a large quantity of gas just below that the well was utilized by the Mountain State Gas Company in its lines for several years. Finally the Associated Producers Company drilled in a well on the Baumgardner farm early in 1898 which started off at 20 barrels an hour, and the pool was thereafter rapidly developed. The record of the old Hamilton well No. 1 as given by the South Penn Company is as follows:

Hamilton Well No. 1, on Whiskey Run, Ritchie county, W. Va.

		Feet.
Conductor	14 to	14
Red rock	26 "	40
Limestone	5 "	45
Slate, blue	10 "	55
Sand, white	115 "	170
Slate, blue	10 "	180
Red rock	5 "	185
Slate, blue	15 "	200
Slate, brown	5 "	205
Limestone shells	3 "	208
Red rock	10 "	218
Blue limestone	15 "	233
Sand, white	30 "	263
Red rock	25 "	288
Slate, blue	20 "	308
Red rock	50 "	358
Slate, blue	40 "	398
Limestone	5 "	403
Slate, blue	30 "	433

		Feet.
Red rock	40 to	473
Slate, blue	17 "	490
Sand, white	15 "	505
Slate, white	13 "	518
Slate, blue	20 "	538
Pink rock	5 "	543
Slate, dark	5 "	548
Slate, light blue	52 "	600
Red rock	10 "	610
Slate, brown	10 "	620
Slate, black	15 "	635
Red rock	40 "	675
Sand, white	10 "	685
Red rock	75 "	760
Slate, white	5 "	765
Red rock	20 "	785
Slate, blue	30 "	815
Coal, hard	5 "	820
Slate, dark	15 "	835
Red rock	30 "	865
Slate, brown	75 "	940
Coal, hard	5 "	945
Slate, blue	40 "	985
Slate, black (cased 6¼ 1,020 ft.)	35 "	1,020
"*Cow Run*" *sand*	20 "	1,040
Sand, white	5 "	1,045
Slate, block	90 "	1,135
Sand and limestone	10 "	1,145
Slate, blue	10 "	1,155
Slate, black	15 "	1,170
Slate, blue	90 "	1,260
Sand, and slate	36 "	1,296
Slate, black	30 "	1,326
Slate, white	10 "	1,336
Slate, black	79 "	1,415
Sand, gray	5 "	1,420
Slate, dark	25 "	1,445
Sand, white	5 "	1,450
Slate, black	65 "	1,515
Sand, gray	75 "	1,590
Slate, dark	70 "	1,660
"*Big Lime*" (*Mountain*)	88 "	1,748
"*Big Injun*" *sand*, white (oil and some gas at 1,749)	1 "	1,749
Sand and limestone, (gas at 1,750)	13 "	1,762
Slate, black	4 "	1,766
Sand, gray	16 "	1,782

The "*Cow Run*" *sand* of this well is certainly *below* the horizon of the "*First Cow Run*," though not deep enough for the "*Second*" one, but it is probably identical with the *Dunkard* or *Upper Mahoning sandstone.*

The record of the Baumgardner well No. 1, of the Associated Producers Company was kept with much care by Prof. John F. Carll, the geologist for that corporation, and he gave the same to the Survey, as follows:

Baumgardner Well No. 1, Whiskey Run Pool.

Conductor	7 to	7
Unrecorded	8 "	15
Coal, Washington, show	... "	...
Unrecorded	33 "	48
Shale, sandy	7 "	55
Sandstone, white (big water flow at 60 ft.)	70 "	125
Slate	25 "	150
Sandstone and sandy shale	55 "	205
Shale, red	25 "	230
Coal, Uniontown (?)	2 "	232
Slate, dark red (10-inch casing at 245 ft.)	83 "	315
Sand and slate, limy	55 "	370
Sandstone, hard, and red slate	25 "	395
Shale, red	45 "	440
Slate, sandy, gray and red	20 "	460
Sandy slate and flaggy sandstone	38 "	498
Coal, Pittsburg	7 "	505
Slate	120 "	625
Slate, sandy, black and red	30 "	655
Slate	85 "	740
Shale, dark "caving"	40 "	780
Slate	205 "	985
Red shale	50 "	1,035
Slate and shale, variegated	35 "	1,070
Slate, black (cased 8¼-inch, 1,110 ft.)	60 "	1,130
Slate, white and gray	145 "	1,275
Slate, dark and limy	80 "	1,355
Coal, Kittanning horizon	2 "	1,357
Slate	33 "	1,390
Sand, gray, and shells	35 "	1,425
Slate, black	25 "	1,450

		Feet.
Sand and shale, dark		20 to 1,470
Dark slate and sand		30 " 1,500
Pottsville No. XII "*Salt Sand*"	sand, white....50 slate, dark....80 sand, white....25 sand, light gray....12 sand, hard.... 6 sand, medium hard, flaky....26 sand, white, friable....21 sand, white, flaky....37	....257 " 1,757
Silicious limestone (*Mountain Limestone*)		20 " 1,777
Sand, fine (top "*Big Injun*," "*Keener*")		18 " 1,795
Sand "pay," sugary		10 " 1,805
Sand, fine, to bottom of well		22 " 1,827

The coal reported at 498 feet comes in at the *Pittsburg* horizon, and is doubtless a representative of that stratum, but probably not so thick as represented, since only a few of the other wells have observed it so far as known. The bottom of this coal would come 490 feet below the *Washington bed* which crops out along the roadside just below the derrick, and 1,290 feet above the top of the "*Big Injun*," which agrees well with what we should expect here.

The "*Salt Sand*" and "*Big Injun*" appear in the drillings to be almost continuous, but when examined with acid the *limestone* horizon separating them, comes out very distinctly.

The Namon Barnes No. 3 a famous producer, is in the valley just below the Baumgardner well, and obtained its oil in two "pays," the first at 1772 feet, producing a light green oil, and that at 1780 feet, a very light amber, as is much of the Whiskey run pool oil. Most operators consider that the production of the pool is from the "*Keener*" horizon of the "*Big Injun*" sand.

A few hundred feet distant from the Baumgardner well, the Associated Producers Oil Co. drilled another

on the land of Mr. Brooks, and the record of this well which was preserved by Mr. Carrl, is so peculiar that it is given here as follows:

Record of Brooks Well No. 1, Whiskey Run Pool.

		Feet.
Unrecorded	530 to	530
Pittsburg coal	5 "	535
Unrecorded	505 "	1,040
Limy shale and sand	10 "	1,050
Unrecorded	50 "	1,100
Sand, grayish white	10 "	1,110
Unrecorded	90 "	1,200
Sand	20 "	1,220
Unrecorded	30 "	1,250
Sand	40 "	1,290
Coal thin		
Sand	10 "	1,300
Unrecorded	150 "	1,450
Coal	5 "	1,455
Unrecorded	145 "	1,600
Slate	10 "	1,610
Sand, white	70 "	1,680
Coal (?) or Asphalt (saturated with oil)	8 "	1,688
"*Big Lime*," (*Mountain*)	67 "	1,755
Big "Injun Sand" — *sand*, fine, soft, oil 1761.... 10; sand, white.... 5; sand and slate.... 4; sand to bottom.... 54	73 "	1,828

The *coaly material* at 1680 feet, resting immediately upon the *Mountain Limestone*, was saturated with petroleum, and described by the drillers as quite difficult to penetrate, "drilling like rubber," as one expressed it. Its location immediately on top of the limestone is so unusual, that I suspected it might be a substance similar to grahamite, and a proximate analysis made by Prof. B. H. Hite, the chemist of the Survey, gave the following results compared with the composition of grahamite:

LIBRARY OF THE UNIVERSITY OF CALIFORNIA

Analysis of bituminous matter from Brooks Well No. 1.

	Brooks No. 1.	*Grahamite.*
Moisture	00.21	00.26
Petroleum	1.40	.....
Volatile matter	34.21	58.37
Fixed carbon	48.82	39.24
Ash	15.36	2.13
	100.00	100.00
Sulphur	1.13	1.25

This analysis shows that the *bituminous matter* is not typical grahamite, though its anomalous stratigraphical position, limited distribution (for other wells drilled all around Brooks No, 1, failed to find the deposit), and saturation with petroleum, are all fairly conclusive evidence that the *bituminous material* is not *coal*, whatever else it may prove to be upon further examination.

The only other locality in the State where *coaly material* has been reported at this horizon is on Leading Creek, in Calhoun county, where in a well drilled by the Sill Oil Company, upon the Metz farm, Mr. W. K. Jacobs reports that five feet of material which resembled *coal* in appearance, was encountered at 1631 feet, only 2 feet above the *Mountain Limestone*, and 108 feet above the "*Big Injun*" *oil sand*. Hence it is quite probable that along this same line where the great fissure on McFarlan was made and filled with the products of petroleum, to be converted into the mineral, grahamite, by subsequent chemical changes, other minor fissures would originate, and not extend to the surface, thus giving rise to such deposits as those struck in the Brooks and Metz borings.

Passing south-east from Whiskey Run 10 miles, to

the vicinity of Harrisville, we find the following geological succession in that region, according to the record of the first well drilled one mile north from the town, by the Keystone Oil and Gas Company :

Keystone Oil & Gas Company's Well No. 1.

Near Ritchie Court House, West Va. Authority, Frank Craig.

		Feet.
Soil	2 to	2
Sand, hard (and shales with *Washington coal* at 35 ft.)	58 "	60
Slate, soft, blue, cave	12 "	72
Sand, white, loose	28 "	100
Limestone, blue	15 "	115
Slate and shells, blue	20 "	135
Red rock	35 "	170
Sand, white	25 "	195
Slate, blue	10 "	205
Red rock	7 "	212
Slate and shells, blue	13 "	225
Red rock	33 "	258
Coal, Uniontown	2 "	260
Sand, white	15 "	275
Slate and shells, blue	50 "	325
Red rock	31 "	356
Sand, white, coarse	15 "	371
Slate, blue, tough	12 "	383
Red rock	7 "	390
Light colored slate and shells	43 "	433
Sand, loose, white	5 "	448
Red rock	29 "	477
Slate, blue	24 "	501
Red rock	5 "	506
Sand "Hurry up" Pittsburg(?)	47 "	553
Slate, blue	28 "	581
Sand, sharp, white	10 "	591
Red rock, light	10 "	601
Slate, blue	20 "	621
Limestone	11 "	632
Red rock	26 "	658
Sandstone, loose, white	10 "	668
Slate, light colored	12 "	680
Red rock	47 "	727
Slate, blue, tough	7 "	734
Sandstone, sharp, white	6 "	740

		Feet.
Red rock	15 to	755
Limestone	5 "	760
Red rock	35 "	795
Slate, blue (*coal* at 833)	58 "	853
Red rock	25 "	878
Sand, hard	7 "	885
Slate, brown	34 "	919
Slate, gray	24 "	943
Red rock	15 "	958
Limestone, light colored	15 "	973
Slate, dark	27 "	1,000
Coal, (*Masontown*)	6 "	1,006
Slate	85 "	1,091
Sand, (*Dunkard, Mahoning*)	105 "	1,196
Slate, blue	23 "	1,219
Sand, hard	15 "	1,234
Slate, white	6 "	1,240
Limestone	31 "	1,271
Sand, sharp	36 "	1,307
Slate, dark (show of coal at 1,320)	38 "	1,345
Sand	6 "	1,351
Slate, white	4 "	1,355
Sand, white	57 "	1,412
Slate and shells, dark	52 "	1,464
Pottsville, No. XII "Salt Sand": sand, white 66; slate, dark 5; sand, hard 8; slate, dark 32; sand, hard, limy 50; sand, hard 4; slate, black 48; sand, dark 8; sand, hard, white, fine-grained 21; slate, black, soft 7	249 "	1,713
Slate, light colored	8 "	1,721
Limestone (*Mountain*)	91 "	1,812
"Big Injun": sand, gas 1,835 to 1,842 80; slate, white 5 6″; sand 16 6″	102 "	1,914
Slate, light colored, to bottom	4 "	1,918

The flow of gas from the "*Big Injun*" here was not large, but its *rock pressure* was 680 pounds to the square inch according to Dr. D. H. Courtney, President of the Keystone Company.

During 1898, a fairly good gas well was drilled by

Ira DeWitt on the Cannon farm, one-half mile further north than the Keystone well, the gas being found in the "*Big Injun*" at 1,724 feet from the surface, which is here 100 feet lower than at the Keystone Company's well.

A short distance north-west from the Cannon well, two small oil wells have been developed on the land of Mr. T. E. Davis by Ira DeWitt and others.

About one mile up the North Fork of Hughes river from the T. E. Davis farm, there have been several wells drilled to the "*Big Injun*" *Sand* in which a small quantity of very light colored oil has been found. One of these wells on the J. N. Wilson farm was sunk to a depth of 2,500 feet, and the following record of the same was given the Survey by Mr. William A. Clark, of Cairo:

The J. N. Wilson Deep Well Record.

Located on Hughes river, between Harrisville and Pennsboro, Ritchie county.

		Feet.
Unrecorded (10-inch casing 100 ft., 8¼-inch at 900 ft.)	900 to	900
Dunkard sand	"	.....
Unrecorded	420 "	1,320
Sand, "casing sand"	"	.....
Unrecorded	414 "	1,734
Sand "*Big Injun*"	54 "	1,788
Unrecorded	347 "	2,135
Shelly sand, show of black oil (Berea)	15 "	2,150
Sand shells and slate	280 "	2,430
Red rock	5 "	2,435
Slate, white	10 "	2,445
Sand shell	20 "	2,465
Red rock	5 "	2,470
Slate and shells to bottom	30 "	2,500

If the *red beds* near the bottom of this well are the same as those which usually overlie the "*Thirty-Foot*"

oil sand of the *Gordon series*, then the *Gordon* and *Fifth Sand* oil horizons were not penetrated here.

About ten miles east from Harrisville, near Holbrook P. O., and close to the Doddridge county line, a deep well has recently been completed on the William Adams farm by the Carter Oil Company, and the following record of it was sent me by Mr. W. H. Aspinwall, of the Carter Company:

William Adams Well No. 1, Near Holbrook, Ritchie County.

		Feet.
Unrecorded	525 to	525
Coal	"	.....
Unrecorded	270 "	795
Sand	10 "	805
Unrecorded	145 "	950
Sand	20 "	970
Unrecorded	70 "	1,040
Sand ("*Gas*")	50 "	1,090
Unrecorded	15 "	1,105
Sand	50 "	1,155
Unrecorded	65 "	1,220
Sand	55 "	1,275
Unrecorded	45 "	1,320
Sand	60 "	1,380
Unrecorded	60 "	1,440
Sand (strong gas 1,455 to 1,480)	60 "	1,500
Unrecorded	105 "	1,605
"*Big Lime*" (*Mountain*)	69 "	1,674
Sand, "*Big Injun*" (oil 1,686 to 1,689)	47 "	1,721
Unrecorded	184 "	1,905
Sand	20 "	1,925
Unrecorded	15 "	1,940
Sand	74 "	2,014
Unrecorded to bottom	656 "	2,670

About a five barrel well in the "*Big Injun*" *sand.*

In this record the driller has termed the sands at 1,925, and 1,940, the *Berea* horizon, but this I think erroneous, these sands being simply a sandy portion of the

Pocono series, since the interval from the bottom of the "*Big Injun*" *sand* to the *Berea* is seldom less than 340 feet, and often runs to 380, even as far west as the Ohio river.

About four miles east from the location of the Adams well, and just over the Ritchie county line in Doddridge, near Oxford P. O., a well was drilled by the Carter Oil Company, on the land of C. P. Broadwater, which gives the following record, according to Mr. W. H. Aspinwall:

C. P. Broadwater Well No. 1, near Oxford Ritchie County.

		Feet.
Unrecorded (water at 230′, 250′ and 525′)	700 to	700
Sand	15 "	715
Limestone	30 "	745
Sand, very hard	5 "	750
Sandy shale and slate	40 "	790
Red shale ("cave" at 810 ft.)	50 "	840
Blue sandy shale	35 "	875
Blue sand and shale	52 "	927
Coal	3 "	930
Dark shale	35 "	965
Sand, *Dunkard* (oil show)	50 "	1,015
Dark shale and limestone	45 "	1,060
Sand, hard	10 "	1,070
Dark shale, black slate and limestone	90 "	1,160
Blue sandy shale and sand in streaks	103 "	1,263
Slate, black	10 "	1,273
Coal, *Kittanning*	4 "	1,277
Slate, black	15 "	1,292
"*Salt Sand*": sand 55; *coal* 3; slate, black 43; sand 53; slate, black 10; *coal* 3; slate, black 11; sand, white 35; sand, dark 40; dark shale and sand 19	272 "	1,564

	Feet.
"*Big Lime*" (*Mountain*)	18 to 1,582
Dark lime, shale and hard shell	82 " 1,664
"*Big Injun*" *sand*	24 " 1,688
Unrecorded	342 " 2,030
Berea sand (*Gantz* and "*Fifty-Foot*")	72 " 2,102
Unrecorded to bottom	4 " 2,106

Made less than one barrel a day after shooting in the "*Big Injun*."

The sand identified (correctly) in this record as the *Berea* by Mr. Aspinwall, can be no other than the *Gantz* and "*Fifty-Foot*" *sand* horizon from which oil is produced in the *Rastle pool* of the Lewis-Doddridge line region, 12 miles south-east from Oxford.

A *Gordon Sand well* has recently (February 1st, 1899,) been developed by the Carter Oil Company about seven miles above Oxford, on the South Fork of Hughes river, and eight miles nearly due south from West Union, the county seat of Doddridge. The well which is now (March 1st) producing 50 barrels daily, is on the S. W. Stout farm, and through the kindness of Mr. W. H. Aspinwall of the Carter Company, the record of this interesting well is here given, as follows:

S. W. Stout Well No. 1, South Fork of Hughes River, Doddridge County.

	Feet.
Unrecorded	965 to 965
Sand	65 " 1,030
Unrecorded	190 " 1,220
Sand ("*Salt*," in part)	280 " 1,500
Unrecorded	80 " 1,580
Sand (*Maxton, Cairo*)	20 " 1,600
Unrecorded	80 " 1,680
"*Big Lime*" (*Mountain*)	25 " 1,705
"*Big Injun*" sand	95
"*Big Injun*" slate	5
"*Big Injun*" sand	55
"*Big Injun*"	155 " 1,860
Unrecorded	583 " 2443
Gordon sand, all "pay"	5 " 2,448
Unrecorded to bottom	36 " 2,484

The finding of this deep sand which is certainly one of the "*Gordons*," (counting the "*Thirty-Foot*," *Campbell's Run*, *Whetstone Run*, and *Flat Run sands*, as constituting the "*Gordon*" *group*,) so far to the south-west, was quite a surprise to the oil fraternity, and it leads to the hope that this deep group of *Venango sands* may be found still further to the south-west, since the accompanying red beds occur in the J. N. Wilson, well, near Harrisville on the north, and in the Norris well at Glenville (page 260) on the south. Wherever these *Catskill red shales* were deposited, it is possible that some beds of coarse sand may be found in the same region, not far away, and these *oil reservoirs* can be found only by means of the drill, which can be greatly aided and directed through a study of the dip and strike of the outcropping beds. The absence of the *Pittsburg coal* from the Stout well record makes it impossible to determine the exact horizon of the producing sand, but that it is one of the several "*Gordon*" *sand* horizons ("*Thirty-Foot*," *Campbell's Run*, *Whetstone Run*, or *Flat Run*) of Marion and Monongalia counties, cannnot be doubted, since its stratigraphical position is 738 feet below the top of the "*Big Injun*" *sand*, and this interval when compared with the records of the wells in the Jarvisville pool, 15 miles distant (pages 252 to 254 of this volume), will be seen to confirm the above conclusion.

Near Miletus, Doddridge county, ten miles north-east from the Stout farm, a well was bored by Murphy, Williams and others in 1884, on the Maxwell lands. It begins about ten feet above the level of the *Washington coal*, and the record is as follows, according to Mr. J. G. Williams, one of those interested in the well :

Maxwell Well No. 1, near Miletus, Doddridge County.

	Feet.
Derrick floor about 900 feet above tide.	
Unrecorded	587 to 587
Pittsburg coal	
Unrecorded	1,333 " 1,920
"*Big Injun*" *Sand* (gas at 1955 and 2100)	185 " 2,105
"*Squaw Sand*"	150 " 2,255
Unrecordcd	125 " 2,380
Gantz sand	35 " 2,415
Slate	5 " 2.420
Fifty-Foot sand	40 " 2,460
Slate	115 " 2,575
Sand (gas for boiler)	28 " 2,603
Unrecorded	37 " 2,640
Shells and shaly sandstone (gas at 2650)	20 " 2,660
Shells and slate	10 " 2,670
Gordon sand, pebbly (strong gas)	30 " 2,700
Shells and slate to bottom	230 " 2,930

This is the structure shown in the Lynch and Goff wells near Cherry Camp, six miles north-east from Miletus, and as the "*Thirty-Foot*" *sand* which is gas and oil bearing there, occurs at 2080 feet below the *Pittsburg coal*, and is split into two sands by 5 to 10 feet of slate, the gas horizon at 2650 feet, and the sand at 2670 feet called "*Gordon*" in the Maxwell well above, would appear to come at the same horizon, since the top of the latter is 2083 below the Pittsburg vein, while the gas above occurs at (2650—587), 2063 feet below the same datum.

The *Gantz* and *Fifty-Foot* sands appear to be represented by the beds at 2380 feet, and 2420 feet, respectively, while the sand with gas at 2575, or 1988 feet below the *Pittsburg coal* would come at the horizon of the gas sand in the Slusser well, near Big Isaac P. O., four miles south-east from Miletus, where the South Penn Oil Company several years ago found a very large flow of gas at 2000 feet below the *Pittsburg coal.*

About one mile north-west from Long Run Station on the B. & O. R. R. and five miles from Miletus, a deep well was drilled on the land of J. D. Crabtree, by the South Penn Oil Company, which gives the following succession :

J. D. Crabtree Well No. 1.

On the farm of J. D. Crabtree, in Grant District, Doddridge county, near Long Run Station on the B. & O. R. R. Authority, South Penn Oil Company.

		Feet.
Slate and limy shells	85 to	85
Slate	135 "	220
Sand, white	20 "	240
Slate	30 "	270
Sand, white	60 "	330
Coal, *Mapletown*, (*Sewickley*), trace		
Slate	15 "	345
Sand, (water)	20 "	365
Slate	68 "	433
Coal, Pittsburg	3 "	436
Slate and shells	184 "	620
Sand, black	10 "	630
Slate	115 "	745
Red rock	97 "	842
Sand, "Hurry Up"	46 "	888
Slate	92 "	980
Dnnkard sand (*Mahoning*)	45 "	1,025
Slate	63 "	1,088
Coal (*Upper Freeport*)	5 "	1,093
Slate	31 "	1,124
Sand (gas)	45 "	1,169
Slate	10 "	1,179
Sand	59 "	1,238
Slate	19 "	1,257
Sand ("*Salt*")	143 "	1,400
Slate, shells and limestone	230 "	1,630
Slate ("Pencil")	10 "	1,640
"*Big Lime*" (*Mountain*)	77 "	1,717
"*Big Injun*" *Sand*	79 "	1,796
Light slate, light sand and shells	148 "	1,944
Sand, dark	122 "	2,066
Slate	298 "	2,364
Sand	11 "	2,375

	Feet.
Slate	67 to 2,442
Sand	4 " 2,446
Slate	2 " 2,448
Sand	3 " 2,451
Slate, light	72 " 2,523
Slate, pink	5 " 2,528
Sand, gray ("*Thirty-Foot*")	2 " 2,530
Slate, black to bottom	171 " 2,701

The *pink* (red) slate at 2,528 would seem conclusive evidence that the *gray sand* horizon immediately below, is a representative of the "*Thirty-Foot*" *sand*, of the Lynch and Goff wells in Harrison, since that stratum is there found immediately below a *red rock*, and at practically the same horizon below the *Pittsburg coal* as in the Crabtree well, the interval being 2,092 feet in the latter, and 2,082 feet in the Lynch well.

The *Sedalia gas pool* of Doddridge county is situated about two miles west from the Harrison county line, and six miles north-west from the Goff and Lynch wells near Cherry Camp, to which reference has been made on a preceding (252) page.

The Carter Oil Company has recently (November, 1898), completed a well near Sedalia, which proved to be an enormous gasser. The well is located on the Camden heirs land, Robinson's fork of McElroy creek, near Sedalia, about 10 miles due north from Miletus, and its record is as follows, according to Mr. W. H. Aspinwall, of the Carter Oil Company:

Camden Heirs Well No. 1, Near Sedalia, Doddridge County.

	Feet.
Unrecorded	715 to 715
Pittsburg coal	" .....
Unrecorded ("cave" at 805 ft.)	349 " 1,064
"Little" Dunkard sand	" .....

	Feet.
Unrecorded	536 to 1,600
"Salt Sand"	" .
Unrecorded	175 " 1,775
Maxton Sand	" .
Unrecorded	190 " 1,965
"Big Lime" (*Mountain*)	75 " 2,040
"Big Injun" Sand (gas)	102 " 2,142
Unrecorded	627 " 2,769
Sand, "Thirty-Foot," (very large gasser)	31 " 2,800

Mr. Aspinwall adds "the *rock pressure* was about 900 pounds, but the volume was not obtained since it was so great that the mercury was blown out of the guage." This is a very important record, since it serves to connect the great gas horizon, which has already been followed, (pages 230-254), as the *"Thirty-Foot" sand* across Monongalia, Marion, and Harrison on the east, into Doddridge at Miletus, with the deep sand wells further west, because the gas well on the Lynch farm near Cherry Camp, Harrison county, is not more than six miles south-east from Sedalia. Then, since the top of the gas sand (*"Thirty-Foot"*) in the Lynch well was found at 2,082 feet below the *Pittsburg coal*, and was 37 feet thick, and as the top of the gas sand in the Sedalia well was struck at 2,054 feet below the same coal, it would appear very probable that the two sands are one and the same, and that the *Sedalia gas sand* could not be identical with either the *Flat Run* or *Whetstone Run "Gordon"* horizons of Marion, even if this gas sand could be the same as the *Campbell's Run "Gordon,"* the one next below the *"Thirty-Foot"* horizon.

The *Center Point oil pool*, in McClellan District, Doddridge county, lies five miles north-west from Sedalia, and was first opened by a well on the Sullivan heirs' land early in 1892. The well was drilled by the South

Penn Oil Company, from whose books the following record was taken :

Sullivan Heirs' Well No. 1.

On the farm of the Sullivan Heirs, near Center Point, Doddridge county. Authority, South Penn Oil Company.

		Feet.
Top rock	20 to	20
Red rock	50 "	70
Slate	27 "	97
Sand	26 "	123
Red rock	12 "	135
Slate	15 "	150
Sand	5 "	155
Red rock	17 "	172
Slate	15 "	187
Coal	8 "	195
Sand	18 "	213
Slate	7 "	220
Limestone	98 "	318
Slate and shells	101 "	419
Coal	6 "	425
Slate	12 "	437
Limestone	24 "	461
Slate	33 "	494
Sand	31 "	525
Limestone	6 "	531
Sand	28 "	559
Slate	47 "	606
Sand	30 "	636
Red rock	8 "	644
Limestone	50 "	694
Red rock	20 "	714
Limestone	69 "	783
Red rock	27 "	810
Limestone	41 "	851
Slate	16 "	867
Limestone	37 "	904
Slate	11 "	915
Limestone	7 "	922
Slate	90 "	1,012
Sand, Dunkard (Mahoning)	101 "	1,113
Limestone	54 "	1,167
"*Gas Sand*" — sand, (gas) 28; slate, " break" 22; sand, (gas) 40	90 "	1,257

		Feet.
Limestone		51 to 1,308
"*Salt Sand*"	salt sand 168 limestone 12 sand 28 slate and shells 59 sand 26	293 " 1,601
Slate		9 " 1,610
Limestone		40 " 1,650
Red rock		36 " 1,686
Limestone		13 " 1,699
Red rock		11 " 1,710
Slate		9 " 1,719
Limestone		31 " 1,750
Slate, "cave," ("*Pencil*")		15 " 1,765
Limestone (*Mountain*)		58 " 1,823
"*Big Injun*"	sand, gray "*Keener*" 13 slate 2 sand, white 20 sand, dark gray 12 sand, white 40	87 " 1,910

The coal at 419 feet is hardly deep enough for the *Pittsburg bed*, since the Washington coal is only 20 feet above water level at Center Point, and then it would give an interval of 1,400 feet between the *coal* and the top of the "*Big Injun*" *sand*, which is apparently too great. The coal in question is probably the *Mapletown* (*Sewickley*) of the drillers.

The Center Point region proved the beginning of a large oil pool in the "*Big Injun*" *sand*, and numerous other wells were drilled in the vicinity.

The Mahala Sweeney No. 1 gives some details from the vicinity of Center Point, not shown in the previous record, and reads as follows :

Mahala Sweeney Well No. 1.

Drilled in 1894, on the farm of Mahala Sweeney, near Center Point, Doddridge county. Authority, South Penn Oil Company.

	Feet.
Rock	29 to 29
Red rock	31 " 60

		Feet.
Slate	29 to	89
Sand	15 "	104
Red rock	27 "	131
Slate	21 "	152
Limestone (trace of *coal*)	33 "	185
Sand	35 "	220
Unrecorded	88 "	308
Slate and shells	106 "	414
Coal	3 "	417
Slate	35 "	452
Limestone	21 "	473
Pittsburg coal	4 "	477
Slate	13 "	490
Sand	78 "	568
Slate	32 "	600
Sand	28 "	628
Limestone	67 "	695
Red rock	24 "	719
Limestone	25 "	744
Red rock	83 "	827
Limestone	48 "	875
Slate	26 "	901
Limestone	64 "	965
Slate	15 "	980
Limestone	85 "	1,065
Dunkard Sand (*Mahoning*)	84 "	1,149
Slate	14 "	1,163
Sand	21 "	1,184
Limestone	16 "	1,200
"Gas" sand (*Freeport*)	66 "	1,266
Slate	35 "	1,301
"*Salt Sand.*" (salt sand 90; slate 15; sand 104; slate and shell 64; sand 10)	283 "	1,584
Limestone	56 "	1,640
Red rock	32 "	1,672
Limestone	39 "	1,711
Slate	3 "	1,714
Limestone	30 "	1,744
Slate ("*Pencil*")	4 "	1,748
Limestone (*Mountain*)	69 "	1,817
"*Big Injun*" *Sand*, gas and oil at 1832; break in sand at 1903; gas at 1911; first "pay" 1924; salt water 1929	112 "	1,929

Here the interval from the Pittsburg coal to top of

the "*Big Injun*" is only 1340 feet. The gas and oil "pay" at 1832 feet would represent the "*Keener*" horizon at the top of the "*Big Injun*" formation.

In 1894 the South Penn Oil Company drilled a well within one-half mile of Center Point on the land of George Cumberledge, and proving small in the "*Big Injun*" *sand*, it was sunk on down through the *Venango group*, thus giving the following succession:

George Cumberledge Well No. 1.

On the farm of George Cumberledge, in McClellan District, Doddridge county, near Center Point. Authority, South Penn Oil Company.

		Feet.
Conductor	36 to	36
Limestone	30 "	66
Slate	20 "	86
Limestone and slate (cased 10-inch at 266)	180 "	266
Limestone(?), *Pittsburg coal* at bottom	174 "	440
Limestone and sand (water)	25 "	465
Slate, black	50 "	515
Red rock	35 "	550
Slate	180 "	730
Red rock	250 "	980
Dunkard Sand (cased 8¼-inch at 1000)	35 "	1,015
Slate	40 "	1,055
Sand (water, cased 6⅝-inch at 1200) *Freeport*	150 "	1,205
Slate	90 "	1,295
"*Salt Sand*"	221 "	1,516
Red rock and limestone	203 "	1,719
"Pencil" slate and *limestone* (*Mountain*)	68 "	1,787
"*Big Injun*" *sand* oil at 1789; gas 1865; cased 5 3-16-inch at 1788	113 "	1,900
Slate, black	34 "	1,934
Sand, black and gray	25 "	1,959
Slate	50 "	2,009
Sand, black	100 "	2,109
Slate	25 "	2,134
Limestone	35 "	2,169
Sand, gray	41 "	2,210
Slate and shells	90 "	2,300
Gantz and "Fifty-Foot" — sand, black, *Gantz* 45; slate 10; sand, hard, gray "*Fifty-Foot*" 20	75 "	2,375
Slate and sand shells	116 "	2 491

		Feet.
Red sand	15 to	2,506
Slate and shells	55 "	2,561
Sand, white, ("*Thirty-Foot*"), gas at 2,561	10 "	2,571
Slate	40 "	2,611
Slate and limy shells to bottom	269 "	2,880

The 15 feet of *red sand* in this well struck 704 feet below the top of the "*Big Injun*" *sand*, corresponds exactly to the 25 feet of *red rock* in the Lynch well near Cherry Camp, Harrison county, struck at 745 feet below the "*Big Injun*," and, therefore, the *gas horizon* in the Cumberledge well at 774 feet below the "*Big Injun*," is most probably in the same sand as that in the Lynch well at 784 feet below the same horizon, or 2,082 feet below the *Pittsburg coal*, viz, the "*Thirty-Foot*" *sand*.

The drillers have recorded too much *limestone* in the Cumberledge well between 86 feet and 440, since much of this called *limestone*, is probably only gray shale slightly limy.

Further down McElroy creek, to the north in the region of the *Flint Creek* and *Shirley oil pools*, a deep well was drilled by the South Penn Oil Company on the land of J. D. McReynolds, two miles south-east from the mouth of Big Flint, and it exhibits the following succession:

J. D. McReynolds Well No. 1.

On the farm of J. D. McReynolds, in Grant District, Doddridge county, two miles south-east from mouth of Big Flint Creek, Authority, South Penn Oil Company.

		Feet.
Conductor	18 to	18
Limestone	40 "	58
Red slate	10 "	68
Limestone	25 "	93
Sand and limestone	75 "	168

		Feet.
Coal	2 to	170
Limestone	10 "	180
Red slate	15 "	195
Limestone	104 "	299
Slate, black	18 "	317
Limestone	10 "	327
Slate, red	16 "	343
Sand	41 "	384
Red slate	10 "	394
Limestone	26 "	420
Pittsburg coal	4 "	424
Limestone and sand	117 "	541
Slate	50 "	591
Sand	10 "	601
Slate	33 "	634
Limestone	25 "	659
Slate, red	5 "	664
Slate, blue	75 "	739
Sand and limestone	96 "	835
Slate, red	30 "	865
Sand	25 "	890
Slate	45 "	935
Dunkard sand	20 "	955
Slate	10 "	965
Limestone and sand	50 "	1,015
Slate	20 "	1,035
Limestone	108 "	1,143
Slate	95 "	1,238
Sand	50 "	1,288
Slate	20 "	1,308
"*Salt Sand*" — sand 22; limestone 25; sand 30; slate 30; sand 63; slate, black 20; sand 50	240 "	1,548
Slate, blue	30 "	1,578
Slate, red	75 "	1,653
Slate, black	25 "	1,678
Limestone	22 "	1,700
Sand	40 "	1,740
Big Lime (Mountain)	53 "	1,793
"*Big Injun*" *sand*	117 "	1,910
Slate	40 "	1,950
Sand	10 "	1,960
Slate	30 "	1,990
Sand and limestone	110 "	2,100

	Feet.
Slate	100 to 2,200
Limestone	60 " 2,260
Sand	40 " 2,300
Slate	150 " 2,450
Limestone	50 " 2,500
Slate	12 " 2,512
Sand, ("*Thirty-Foot*"), show of oil at 2,517 ; strong gas at 2,520.	8 " 2,520
Total depth	... " 2,520

The sand at 2512 feet, 2088 feet below the *Pittsburg coal*, and 717 feet below the top of the "*Big Injun*" *sand*, corresponds so well to the horizon of the "*Thirty-Foot*," that there can be little doubt of the identity.

The Hardman oil pool lies along the line between Doddridge and Tyler counties, and was discovered by Murphy and Jennings in 1895. The oil was found in the "*Big Injun*" *sand* which there lies 1290 to 1300 feet below the *Pittsburg coal.* The first well produced at the rate of 500 barrels daily. After the deep sand territory of Tyler county had been developed near Alva in 1897, some of the wells in the Hardman pool that had proven small or dry in the "*Big Injun*" were drilled on down to the deep sand. One of these was the O. W. O. Hardman No. 53, and it gave the following record, taken from the books of the owners, through their kind permission :

O. W. O. Hardman Well No. 53, Tyler County, near Doddridge.

	Feet.
Unrecorded (10-inch casing 225 ft.)	822 to 822
Pittsburg coal	....
Unrecorded (8¼-inch casing 1250 ft.)	1,290 " 2,112
"*Big Injun*" *sand*	....
Unrecorded (6⅝-inch casing 2260, 5 3-16-inch 2324)	763 " 2,875
"*Gordon*" *Stray*	....
Unrecorded	27 " 2,902
"*Gordon*" *Sand* ("pay" 2902-2907 ft.)	6 " 2,908
Unrecorded to bottom	14 " 2,922

This deep sand is known as the "*Gordon*" all through Tyler and Wetzel, and the sand immediately above, from which it is usually separated by 5 to 10 feet of slate is called the "*Stray*," and is the great gas sand horizon of the Tyler-Wetzel district. As will be seen from the record this "*Gordon Stray*" lies 2053 feet below the Pittsburg coal, and therefore would appear to be the same *sand horizon* as the "*Thirty-Foot*" on the Goff, Lynch and Maxwell lands to the east which we have followed west by way of Long Run; Sedalia, Center Point and Big Flint. Then, too, the "*Thirty-Foot*" on the Goff land near Cherry Camp was split into two sands by a few feet of slate, just as this "*Gordon*" *sand* is all through the Tyler-Wetzel district. It is barely possible that the Tyler-Wetzel "*Gordon*" sand may be identical with the *Campbell's Run* "*Gordon*" of Marion-Monongalia, the "*Stray*" above representing the "*Thirty-Foot*" sand of that region, but it cannot be either the *Whetstone Run*, or *Flat Run* "*Gordon*" *sand* of Marion.

In No. 12 Hardman some oil was found in the *Maxton sand* horizon, as shown by the following record:

O. W. O. Hardman Well No. 12, Doddridge County, near Tyler.

			Feet.
Unrecorded	670	to	670
Pittsburg Coal	.....	"	.....
Unrecorded	1,145	"	1,815
Maxton Sand (flowed dark green oil from 1850 to 1856)	41	"	1,856
Unrecorded	162	"	2,018
'*Big Injun*" *sand*, oil show, 2018, top 1st "pay" 2065, 2nd "pay" 2085, good sand, getting inferior at bottom	97	"	2,115

The *Maxton sand* horizon is supposed to be the basal portion of the "*Salt Sand*," or Pottsville series, and

identical with the *Cairo oil* horizon just above the *Mountain limestone.* But if there are *red beds* immediately above the *Maxton sand* on the Hardman farm (which the records do not disclose,) then the *Maxton* would not be identical with the *Cairo sand,* but would belong in the Mauch Chunk, No. XI series, instead of in No. XII, of Rogers.

The deep sand pool of Tyler county in the Stringtown and Alva region was discovered by the South Penn Oil Company in 1897, the same year that Murphy, Jenning & Co. opened up the Mills pool in Wetzel, the latter, Piney Fork and Alva being practically one continuous pool of *deep sand* oil, from the same horizon as that shown in the Hardman wells just given.

This is evident by the following record from the Peter Horner well No. 1, at Alva P. O., Tyler county, near the Doddridge line:

Peter Horner Well No. 1, at Alva, Tyler County.

	Feet.
Unrecorded	620 to 620
Pittsburg coal	" .....
Unrecorded	1,326 " 1,946
"*Big Injun*" *sand*	161 " 2,107
Unrecorded	555 " 2,662
"*Stray*" *sand* (oil at 2,672 ft.)	10 " 2,672
Unrecorded	10 " 2,682
"*Gordon*" *sand* (oil at 2,685 ft.)	13 " 2,695
Unrecorded to bottom	5 " 2,700

Here the top of the "*Stray*" of the drillers comes 2,042 feet below the *Pittsburg coal* and can be no other than the "*Thirty-Foot*" of previous records.

Passing northward now to the Mills pool of Murphy and Jennings in Wetzel county, we find the following succession at their No. 11 Mills, as taken from their books:

Record of Mills Well No. 11, Wetzel County.

			Feet
Unrecorded (10-inch casing 560 ft.)	785	to	785
Pittsburg Coal	"		.....
Unrecorded (8¼-inch casing, 1,555 ft.)	1,310	"	2,095
"*Big Injun*" *Sand* (oil at 2,190 ft.)	"		.....
Unrecorded (6⅝-inch casing 2,128 ft., and 591 ft. of 5 3-16-inch liner set at bottom)	760	"	2,855
"*Stray*"	20	"	2,875
"Break" (slate)	8	"	2,883
"*Gordon*" *sand* (bottom of "pay" 2,890 ft.)	14	"	2,897
Unrecorded to bottom of well	5	"	2,902

This gives an interval of 2,070 feet from the Pittsburg coal to the "*Stray*" of the Mills pool, which proves it to be the same as the "*Stray*" at Alva in Tyler, and, therefore, the "*Thirty-Foot*" of Marion and Monongalia, just below the *Catskill red beds.*

At Piney Fork village, the western margin of the Piney Fork oil pool, the structure is shown by the record of Israel Miller well No. 3, of the South Penn Oil Company, as follows:

Israel Miller Well No. 3.

On the farm of Israel Miller, at Piney Fork, Wetzel county. Authority, South Penn Oil Company.

			Feet.
Unrecorded	551	to	551
Pittsburg coal	"		.....
Unrecorded	1,325	"	1,876
"*Big Injun*" *sand*	186	"	2,062
Unrecorded	528	"	2,590
"*Stray*" *sand*	"		.....
Unrecorded	28	"	2,618
"*Gordon*" *sand* (oil, 2,620)	18	"	2,636
Unrecorded to bottom	4	"	2,640

Here the interval from the *Pittsburg coal* to the top of the "*Stray*" or "*Thirty-Foot*" is only 2,039 feet, and to the "*Gordon*" below, 2,067 feet.

The same kind of thinning is shown still further on the extreme western edge of the Piney Fork-Alva deep sand pool in Tyler county. The record of Jasper Glover No. 1, on this *western edge* in Tyler county illustrates this as follows, according to the South Penn Oil Company's books:

Jasper Glover Well No. 1, Tyler County.

	Feet.		
Unrecorded	810	to	810
Pittsburg coal		"	.....
Unrecorded	1,290	"	2,100
"Big Injun" sand	165	"	2,265
Unrecorded	559	"	2,824
"Stray" sand	23	"	2,847
"Gordon" sand (oil, 2,849)	12	"	2,859
Unrecorded to bottom	17	"	2,876

Here the interval from the *Pittsburg coal* to the *"Stray" sand* is reduced still further to only 2,014 feet.

The extreme *eastern side* of the deep sand development of Tyler county, shows the following succession on the land of Christina McCoy, according to the South Penn Oil Company:

Christina McCoy Well No. 1, Tyler County.

	Feet.		
Unrecorded	930	to	930
Pittsburg coal	.....	..	.....
Unrecorded	1,350	"	2,280
"Big Injun" sand	110	"	2,390
Unrecorded	630	"	3,020
"Stray" sand	22	"	3,042
"Gordon" sand (oil 3046)	16	"	3,058

Here the interval from the Pittsburg coal to the *"Stray"* has increased to 2090 feet, and it measures 2112 feet to the top of the *"Gordon"* portion, which,

in view of this tendency to *thicken eastward*, I think we may consider as identical with the *Campbell's Run* "*Gordon*" of Marion and Monongalia, and which is most probably the equivalent of the true *Gordon sand* of Washington county, Penna.

Near Lot P. O., at the mouth of Richwoods Run, 7 miles above Pine Grove, the Carter Oil Company has drilled a well on the land of G. W. Anderson, beginning about 10 feet below the horizon of the *Washington coal* which outcrops there along the road. The record reads as follows:

G. W. Anderson Well No. 1, Lot P. O., Wetzel County.

Authority, Carter Oil Company.

		Feet.
Unrecorded	220 to	220
Coal (*Uniontown*)	3 "	223
Unrecorded	207 "	430
Coal, Mapletown (*Sewickley*)	8 "	438
Unrecorded	62 "	500
Coal, Pittsburg	10 "	510
Unrecorded	480 "	990
Sand "Little" Dunkard	30 "	1,020
Unrecorded	230 "	1,250
Sand, "Big" Dunkard	40 "	1,290
Interval	30 "	1,320
"Salt Sand"	220 "	1,540
Unrecorded	160 "	1,700
"Big Lime" (*Mountain*)	50 "	1,750
"Big Injun" Sand	250 "	2,000
Unrecorded	525 "	2,525
"Stray" and *Gordon sands*, strong gas 2540 to 2560, small show of oil at 2562 and 2588 ft	63 "	2,588

This is at the *western* edge of the deep sand oil pool and in sight of the famous *Owl's Head gas pool* which occupies the crest of an anticlinal arch that crosses Big Fishing creek here about one mile below Lot. The interval from the *Pittsburg coal* to the "*Stray*" has *thinned* to

2015 feet, the same as in the Jasper Glover well in Tyler county.

The South Penn Oil Company drilled the first well in the Owl's Head gas district, on the land of D. H. Cox, which proved a large gasser in the "*Big Injun*" *sand*, but was drilled through the entire *Venango group*, and developed some gas horizons in those beds. The record of this well reads as follows, according to the South Penn Oil Company's log:

D. H. Cox Well No. 1, in Owl's Head Region, Wetzel County.

On the farm of D. H. Cox, in Grant District, Wetzel county, W. Va. Authority, South Penn Oil Company.

		Feet.
Conductor	16 to	16
Limestone, blue, hard	30 "	46
Soapstone	10 "	56
Limestone, blue	30 "	86
Sand, white	10 "	96
Soapstone	31 "	127
Coal, (*Washington*)	3 "	130
Soapstone	140 "	170
Limestone, white	20 "	190
Sand, reddish	6 "	196
Soapstone	16 "	212
Slate, black	20 "	232
Red rock	4 "	236
Limestone, white	8 "	244
Limestone, sandy	10 "	254
Soapstone	20 "	274
Slate, black	12 "	286
Soapstone	15 "	301
Slate, black	18 "	319
Red rock	35 "	354
Soapstone	9 "	363
Limestone, sandy	5 "	368
Slate, black	4 "	372
Limestone, black	5 "	377
Sand and limestone	4 "	381
Slate	25 "	406
Limestone	43 "	449

			Feet.
Slate	4	to	453
Sand	5	"	458
Limestone	67	"	525
Sand and shells	10	"	535
Slate, black	20	"	555
Limestone	21	"	576
Slate	11	"	587
Red rock	5	"	592
Pittsburg coal	16	"	608
Red rock	4	"	612
Slate	4	"	616
Red rock	25	"	641
Limy sand	16	"	657
Slate	10	"	667
Limestone	18	"	685
Slate	24	"	709
Limestone	30	"	739
Slate	23	"	762
Limestone	12	"	774
Red rock	20	"	794
Limestone	30	"	824
Limestone, red	15	"	839
Limestone	10	"	849
Sand	22	"	871
Limestone	40	"	911
Sand	30	"	941
Limestone	20	"	961
Slate and shells	10	"	971
Red rock	20	"	991
Limestone	5	"	996
"Cave"	5	"	1,001
Slate and sand shells	35	"	1,036
Sand	10	"	1,046
Slate	5	"	1,051
Red rock	25	"	1,076
Limestone	20	"	1,096
Slate	40	"	1,136
Limestone	40	"	1,176
Slate and shells	38	"	1,214
Slate	17	"	1,231
Sand	44	"	1,275
"Cave"	5	"	1,280
Slate	10	"	1,290
Sand	50	"	1,340
Slate and shells	15	"	1,355
Slate	22	"	1,377
Sand, gray	40	"	1,417

		Feet.
Sand	62 to	1,479
Slate	63 "	1,542
Sand	10 "	1,552
Sand shells and limestone	35 "	1,587
Sand	50 "	1,637
Slate, black	63 "	1,700
Red rock	10 "	1,710
Sand (gas)	56 "	1,766
"*Pencil*" *slate*	15 "	1,781
Limestone	91 "	1,872
"*Big Injun*" — sand and limestone 20; sand, grayish white 12; slate 2; sand, hard, white 26; sand, dark gray 18; sand, white 5; sand, dark gray 15; sand, white, (gas at 1,972) 45; sand, gray 8	151 "	2,023
Slate	4 "	2,027
Sand	150 "	2,177
Slate and shells	15 "	2,192
Sand	180 "	2,372
Slate and shells	20 "	2,392
Sandy beds (*Gantz* and "*Fifty-Foot*")	160 "	2,552
Sand	50 "	2,602
Slate	30 "	2,632
Sand, ("*Stray*" and *Campbell's Run* "*Gordon*")	68 "	2,700
Slate and shells	75 "	2,775
Slate	40 "	2,815
Sand (*Flat Run* "*Gordon*," *Fourth*)	2 "	2,817
Slate	20 "	2,837
Sand (*gas*) *McDonald, Fifth*	1 "	2,838
Slate	18 "	2,856
Slate and shells	188 "	3,044

In this record we find the entire *Venango series* represented, including the *McDonald* or *Fifth* at the bottom with some gas in it.

Smithfield, Grant District, Wetzel county, is the center of a large pool of "*Big Injun*" oil which was developed by the South Penn Oil Company. Recently some of the wells which were small or dry in the "*Big Injun*" *Sand* have been drilled into the Venango group

below. One of these, B. W. Peterson No. 34, one-half mile east from the town of Smithfield on the summit of a ridge 500 feet above the valley, gives the following succession according to the South Penn Oil Company:

B. W. Peterson Well No. 34, Near Smithfield, Wetzel Co.

	Feet.
Unrecorded	1,163 to 1,163
Pittsburg coal	7 " 1,170
Unrecorded	500 " 1,670
Dunkard sand	15 " 1,685
Unrecorded	598 " 2,283
"Salt Sand"	57 " 2,340
Unrecorded	38 " 2,378
"Pencil cave"	7 " 2,385
"Big Lime" (*Mountain*)	88 " 2,473
"Big Injun" Sand (gas and oil 2560 ft.)	177 " 2,650
Unrecorded	315 " 2,965
Sand, Gantz	35 " 3,000
Unrecorded	215 " 3,215
"Stray" sand, (*"Thirty-Foot"*)	25 " 3,240
Unrecorded	23 " 3,263
Sand (*Campbell's Run "Gordon"*), gas at 3278 ft.	19 " 3,282

Here we have an interval of 2045 feet from the Pittsburg coal to the "*Stray*" or "*Thirty-Foot*" *sand*, and of 2093 feet to the "*Gordon*" of the drillers, which can be no other than the *Campbell's Run Sand* of Marion and Monongalia, the uppermost of the *three* beds which have borne the name "*Gordon*" in Marion county.

On the Margaret Gump farm about 2 miles northeast from Smithfield, some oil has been found in the deep sand in Well No. 2, as reported by the South Penn Oil Company, as follows:

Margaret Gump Well No. 2.

	Feet.
Unrecorded	970 to 970

		Feet.
Pittsburg coal	10 to	980
Unrecorded	540 "	1,520
Sand, *Dunkard*	80 "	1,600
Unrecorded	300 "	1,900
"*Salt Sand*"	70 "	1,970
Unrecorded	200 "	2,170
Limestone	20 "	2,190
"Pencil cave"	5 "	2,195
"*Big Lime*" (*Mountain*)	71 "	2,266
"*Big Injun*" *sand*	127 "	2,393
Unrecorded	627 "	3,020
Red Sand	20 "	3,040
Unrecorded	24 "	3,064
"*Stray*" ("*Thirty-Foot*")	16 "	3,080
Unrecorded	5 "	3,085
Gordon sand (*Campbell's Run*), 1st "pay" 3092; 2nd "pay" 3097	21 "	3,106

Here we have the *red horizon* coming a few (24) feet above the "*Stray*" or "*Thirty-Foot*," just as it does in so many other wells. The top of the "*Stray*" is here 2084 feet below the *Pittsburg coal*, the same interval as in the Lynch and Goff wells of Harrison, where the *red sand* comes in above. The top of the oil producing sand lies 2105 feet below the *Pittsburg coal*, and is doubtless the equivalent of the *Campbell's Run sand*, or true *Gordon* of Washington county, Penna.

In Margaret Gump No. 1, where the *Pittsburg coal* was struck at 760 feet, some oil was found in a sand at 1,109 feet, 344 feet below the *Pittsburg coal* which is possibly in the upper *Dunkard* horizon.

Near Brink, Wetzel county, 8 miles north of Smithfield, a deep sand well was drilled by the Hartman Oil Company, on the land of J. M. Allen, which gave the following record, according to the books of that Company:

J. M. Allen' Well No. 1, Near Brink, Wetzel County.

			Feet.
Unrecorded	610	to	610
Pittsburg coal		"	.....
Unrecorded	500	"	1,110
Sand, *Dunkard*	65	"	1,175
Unrecorded	160	"	1,335
"Gas" sand	120	"	1,455
Unrecorded	23	"	1,478
"*Salt Sand*" (water at 1,576 and 1,600 ft.)	170	"	1,648
Unrecorded	202	"	1,850
"Pencil cave"	5	"	1,855
"*Big Lime*" (*Mountain*)	50	"	1,905
"*Big Injun*" sand (gas, 1,912, 1,984, and 2,005, little oil at 2,014)	192	"	2,097
Unrecorded	319	"	2,416
Sand	5	"	2,421
Unrecorded	20	"	2,441
Sand, Gantz (?)	10	"	2,451
Unrecorded	227	"	2,678
"*Stray*" sand ("*Thirty-Foot*")	20	"	2,698
Unrecorded	30	"	2,728
"*Gordon*" (*Campbell's Run*) gas at 2,753 ft	25	"	2,753

Here the interval between the "*Stray*," and the "*Gordon*" sands of Wetzel and Tyler has thickened to 30 feet, putting the one 2,068 feet below the *Pittsburg coal*, and the other ("*Gordon*"), 2,118 feet below the same coal bed.

About six miles south-east from Brink and one mile west of Joetown in Marion county, a deep well was drilled by the South Penn Oil Company on the land of S. E. Snyder, which furnishes a representative of most of the *Venango sands*, and as it serves to connect the Wetzel and Tyler deep sand horizons with those of Marion and Monongalia, it is given here for purposes of comparison as follows:

S. E. Snyder Well No. 1.

On the farm of S. E. Snyder, one mile west of Joetown, on Glade Fork

of Bingamon creek, Marion county, West Va. Authority, South Penn Oil Company. Began December 11, 1893, completed March 19th, 1894.

		Feet.
Conductor	10 to	10
Slate and limestone	120 "	130
Sand, white	100 "	230
Limestone	200 "	430
Slate	30 "	460
Coal (*Mapletown, or Sewickley*)	1 "	461
Slate	19 "	480
Limestone	60 "	540
Slate	20 "	560
Pittsburg coal	8 "	568
Slate	44 "	612
Limestone	42 "	654
Slate and Limestone	48 "	702
Red slate	48 "	750
Sand	15 "	765
Red slate	35 "	800
Slate and limestone	38 "	838
Red slate	22 "	860
Limestone	70 "	930
Limestone and Slate	45 "	975
Sand. white, (*Upper Mahoning, Dunkard sand*)	50 "	1,025
Slate	30 "	1,055
Sand, white (*Lower Mahoning*)	51 "	1,106
Limestone	83 "	1,189
Black slate	15 "	1,204
Slate and limestone	36 "	1,240
Coal, (one of the Kittannings)	5 "	1,245
Slate	19 "	1,264
Sand, white	46 "	1,310
Limestone and slate	52 "	1,362
Sand	13 "	1,375
Slate, black	5 "	1,380
Sand, black	42 "	1,422
Slate, brown	19 "	1,441
Limestone	19 "	1,460
Sand, white (top of No. XII)	32 "	1,492
Slate	3 "	1,495
Sand, white	150 "	1,645
Coal	2 "	1,647
Sand	18 "	1,665
Slate, black	38 "	1,703
Sand, white (*Maxton*), gas and oil at 1743, gas and water at 1763, and gas at 1783	105 "	1,808
"*Big Lime*" (*Mountain*)	50 "	1,858

	Feet.
"*Big Injun*" *sand*, (water at 1,943)	132 to 1,990
Slate	30 " 2,020
Slate and limestone	150 " 2,170
Limestone	30 " 2,200
Slate	100 " 2,300
Limestone	50 " 2,350
Limestone and shells	50 " 2,400
Limestone	54 " 2,454
Gantz sand, white	56 " 2,510
Slate	31 " 2,541
"*Fifty-Foot*" *Sand*	30 " 2,571
Red slate	29 " 2,600
Sand	25 " 2,625
Slate	25 " 2,650
Limestone	25 " 2,675
Sand, "*Stray*" ("*Thirty-Foot*")	25 " 2,700
Slate, black	26 " 2,726
Sand, soft, white, *Gordon*, (*Campbell's Run*) oil, 2,731	10 " 2,736
Slate	9 " 2,745
Sand, (*Whetstone Run* "*Gordon*")	15 " 2,760
Slate	40 " 2,800
Sand, white, (*Flat Run* "*Gordon*"), oil at 2,804 feet	16 " 2,816
Slate, soft, blue, to bottom	198 " 3,014

The intervals separating the different oil sands from the *Pittsburg coal* show a still further expansion eastward in this record, viz, to 2,108 feet for the "*Thirty-Foot*," and 2,158 feet for the *Campbell's Run* sand, thus making an increase of exactly 40 feet for each of these members, in the six miles south-eastward from the J. M. Allen well at Brink, Wetzel county. It will also be observed that the interval below the *Pittsburg coal* (2,158′) of the *Campbell's Run* '*Gordon*" sand of this record is almost exactly the same as on Campbell's Run (2,156′) at the type locality, (John Styles well, page 247).

The E. J. Freeland well No. 2, of the South Penn Oil Company, near Metz, Marion county, gives a good record of all the *Venango group* of sands, and with it

we must conclude the Marion county region. This record is as follows, according to the South Penn Oil Company:

E. J. Freeland Well No. 1.

On the farm of E. J. Freeland, near Metz, Marion county. Authority, South Penn Oil Company.

		Feet.
Conductor	28 to	28
Unrecorded (10-inch casing at 130 ft.)	522 "	550
Mapletown coal		
Unrecorded	97 "	647
Pittsburg coal		
Unrecorded	603 "	1,250
Dunkard sand (cased 8¼-inch at 1260 ft.)	30 "	1,280
Unrecorded	45 "	1,325
"*Gas*" *saud*	130 "	1,455
Unrecorded	110 "	1,565
"*Salt Sand*"	75 "	1,640
Unrecorded (cased 6⅝-inch at 1661)	245 "	1,885
"*Pencil cave*"	7 "	1,892
"*Big Lime*" (*Mountain*)	68 "	1,960
"*Big Injun*" *sand* (water, 1960, cased 5 3-16 inch, 2114′)	140 "	2,100
Unrecorded	470 "	2,570
Gantz sand	20 "	2,590
Unrecorded	10 "	2,600
"*Fifty-Foot*" *sand* (gas at 2600′)	35 "	2,635
Unrecorded	35 "	2,670
Sand	30 "	2,700
Unrecorded	35 "	2,735
"*Thirty-Foot*" sand	30 "	2,765
Unrecorded	55 "	2,820
"*Stray*" *sand* (*Campbell's Run*)	13 "	2,833
Unrecorded	8 "	2,841
Gordon sand (*Whetstone Run*)	18 "	2,859
Unrecorded	12 "	2,871
Fourth sand, white, pebbly at top, (*Flat Run*)	35 "	2,906
Unrecorded	12 "	2,918
Sand, white, good (*Fifth*, *McDonald*)	22 "	2,940
Unrecorded	6 "	2,946
Sand, dark	12 "	2,958
Slate to bottom	34 "	2,992

Here we have the entire *Venango series* represented,

and the thickness from the top of the *Gantz* to the bottom of the *Fifth sand* foots up 370 feet.

Passing now 9 miles north-west from Metz to the village of Hundred, Wetzel county, we find the following succession there, as given by the record of the John Jobes well No. 1, of the Carnegie Natural Gas Company, according to the superintendent of the same, Mr. N. Johnston, of Pittsburg:

John Jobes Well No. 1, Near Hundred, Wetzel County.

	Feet.
Unrecorded	950 to 950
Pittsburg coal	" .....
Unrecorded (10-inch casing 1,199′, 8¼-inch 1,515′)	740 " 1,690
"Gas" sand (gas at 1,690 and 1,750)	70 " 1,760
Unrecorded	120 " 1,880
"Salt Sand" (gas at, 1,880)	100 " 1,980
Unrecorded	205 " 2,185
"Big Injun" sand (cased 6⅝-inch, 2,189) gas at 2,195	" .....
Unrecorded	745 " 2,930
Sand	" .....
Unrecorded	60 " 2,990
Big gas strike, (*"Stray," "Thirty-Foot"*)	" .....
Unrecorded	102 " 3,092
Sand, Gordon, (Campbell's Run)	23 " 3,115
Unrecorded	25 " 3,140
Sand, Fourth, (Flat Run)	15 " 3,155
Unrecorded	33 " 3,188
Sand, Fifth, McDonald	12 " 3,200
Unrecorded to bottom	49 " 3,249

"Gas pressure, first minute, in 6⅝-inch casing, 100 pounds; rock pressure, 1,000 pounds.

No gas was found in the sands below 2,990 ft. This would appear to be the *"Stray,"* or *"Thirty-Foot"* sand, the great gas horizon of Wetzel county.

Passing still further west to Cogley Station, B. & O. R. R., half way between Bellton and Cameron, Marshall county, we come to the location of the J. H.

Mackey well of the South Penn Oil Company, where the following succession was recorded:

J. H. Mackey Well No. 1, Near Cogley Station, Marshall County.

Drilled near the Baltimore & Ohio R. R., half way between Cameron and Bellton, in Marshall county. Authority, South Penn Oil Company:

	Feet.
Unrecorded	745 to 745
Pittsburg coal	"
Unrecorded	705 " 1,450
Sand, (*Freeport*)	100 " 1,550
Unrecorded	290 " 1,840
"*Salt Sand*"	75 " 1,915
Unrecorded	5 " 1,920
"*Big Injun*," (gas and oil show at 2,025′)	310 " 2,230
Unrecorded	310 " 2,540
Sand. (*Gantz* and "*Fifty-Foot*")	100 " 2,640
Unrecorded	164 " 2,804
Sand	8 " 2,812
Red rock	3 " 2,815
Slate	5 " 2,820
"*Stray*" *sand*, gas (*Thirty-Foot*)	25 " 2,845
Slate	30 " 2,875
Gordon sand (*Campbell's Run*)	10 " 2,885
Slate	50 " 2,935
Sand, (*Flat Run, Fourth*)	7 " 2,942
Slate and shells	207 " 3,249

The top of the "*Stray*" *sand* is here 2,075 feet below the *Pittsburg coal* and is the gas rock of the Cameron region just west, as also of the Wetzel county field near Pine Grove to the south-west, and appears to be identical with the "*Thirty-Foot*" since it comes immediately below the *red beds*.

About ten miles north-west from Cogley, the Carter Oil Company drilled a well on the Cox farm, five miles north from Loudensville, Marshall county, and the record preserved gives many details of the stratification down to and through the "*Big Injun*" *sand*, as follows:

Cox Well, Wolf Run, Marshall County.

Five miles north from Loudensville, Authority, Carter Oil Company.

		Feet.
Loam	10 to	10
Gravel	5 "	15
Limestone, hard	25 "	40
Red rock	25 "	65
Slate	30 "	95
Limestone, hard	10 "	105
Red rock	5 "	110
Limestone, hard	10 "	120
Red rock	5 "	125
Slate	15 "	140
Coal	2 "	142
Slate	15 "	157
Bluff sand (little water)	30 "	187
Break (little gas)	13 "	200
Slate, black	30 "	230
Slate, white	10 "	240
Limestone	10 "	250
Slate, black	40 "	290
Coal (gas)	6 "	296
Slate	14 "	310
Limestone	15 "	325
Slate	15 "	340
Limestone, hard	50 "	390
Slate	5 "	395
Limestone	10 "	405
Slate	5 "	410
Limestone	75 "	485
Mapletown coal	5 "	490
Slate	20 "	510
Limestone	35 "	545
Slate	5 "	550
Limestone	5 "	555
Slate	20 "	575
Pittsburg coal	5 "	580
Limestone (water)	5 "	585
Slate	5 "	590
Sand	5 "	595
Limestone, very hard	55 "	650
Limestone and slate	100 "	750
Red rock	50 "	800
Slate	25 "	825
Limestone	10 "	835
Slate	10 "	845

		Feet.
"Big Red"	100 to	945
Cow Run sand	15 "	960
Slate	10 "	970
Red rock	20 "	990
Limestone	5 "	995
Slate	105 "	1,100
Dunkard sand	20 "	1,120
Slate	20 "	1,140
Sand	20 "	1,160
Break	35 "	1,195
Coal	5 "	1,200
Slate	10 "	1,210
Gas sand	70 "	1,280
Slate	70 "	1,350
Sand	10 "	1,360
Slate	60 "	1,420
"Salt Sand"	20 "	1,440
Slate	50 "	1,490
Second *"Salt Sand,"* white (water at 1535)	85 "	1,575
Black sand and slate	110 "	1,685
"Big Lime"	75 "	1,760
"Break"	10 "	1,770
"Big Injun" sand to bottom of hole	165 "	1,935

Returning now to the Ohio river region of Pleasants county, we shall follow up the river from St. Mary's, giving a few records to illustrate the stratification along the Ohio valley.

The great Burning Springs anticlinal crosses the Ohio river near Eureka, five miles below St. Mary's, and there brings the *Macksburg* or *Berea sand* much nearer the surface than in the Boaz field below Williamstown, where it is 1943 feet below the top of the first river bottom, on the S. S. Stone farm.

A rich oil pool was discovered by Brown and Boss, of Parkersburg, at Eureka in 1889.

A well drilled on Brother's Island, near Eureka, begins about 30 feet above low water, of which the following record was given me by Mr. C. W. Brockunier, of Wheeling, who was interested in the well:

Brother's Island Well No. 1.

			Feet.
Drive pipe (through clay and gravel)	80	to	80
Unrecorded	120	"	200
Sand, heavy oil		"	.....
Unrecorded	215	"	415
Sand, oil show with water	25	"	440
Unrecorded	100	"	540
Second Cow Run Sand	60	"	600
Unrecorded	40	"	640
Salt water sand ("*Salt Sand*" and "*Big Injun*")	330	"	970
Shales, with 40 feet of black slate at bottom	378	"	1,348
Berea Grit, oil		"	.....

This shows about 40 feet of filling in the river channel here below the bed of the same. The sand at 200 feet is supposed to be the *First Cow Run*, and that at 540 feet the second one.

Another well on the Cook farm up French creek, one mile back from the river gives more detail and starts on the hill. It is as follows, according to Mr. Brockunier:

Cook Farm Well on French Creek, Near Eureka.

			Feet.
Unrecorded (cased 7⅝-inch at 305 ft.)	390	to	390
First Cow Run sand	50	"	440
Dark shales	160	"	600
Sand	48	"	648
Shales	52	"	700
Sand	50	"	750
Shale, black	95	"	845
"*Salt Sand*" ("*Salt sand*" proper and "*Big Injun*," oil 945 ft., oil and gas 1,090 ft., with big pebbles, salt water at 1,125 ft.)	375	"	1,220
Slates and shales, oil show at 1,415	347	"	1,567
Berea Sand	4	"	1,571
Unrecorded to bottom	31	"	1,602

The *Berea sand* varied from 0 to 35 feet in thickness in this region and some of the wells flowed 20 to 30 barrels an hour. The field was of limited area owing

to the rapid dip on each side of the great arch, and the available territory was soon drilled over.

The sand at 390 feet is called the *First Cow Run* by the drillers, and is the same as that struck at 200 feet in the Brother's Island well, while that at 700 feet is supposed to be the *Second Cow Run sand.*

Both of these horizons are prolific in oil in Pleasants county, there being a large pool in the first one just east (2½ miles) from St. Mary's known as the *Broad Run district*, while the "*Big Injun*" and "*Salt Sand*" horizons are also productive in other portions of the county.

Passing northward from Eureka and Belmont the rocks dip down quite rapidly and at St. Mary's the *Berea* horizon is 1900 feet below the river level according to the record of the Tan Lot well in the southern edge of the town, while the *Macksburg coal*, and the great sand-rock above it crop out above the level of the river terrace, and do not disappear below the river until we come to Raven Rock, 4 miles above St. Mary's.

A well was drilled on Grandview Island, near Friendly, 5 miles below Sistersville, by Wheeling parties, who report the finding of 10 feet of *red rock* at 1960 feet, four to five hundred feet below the "*Big Injun*" *sand* which was coarse and pebbly and held some oil at this locality. These *red beds* would belong in the *Catskill series*, and are very probably at the same horizon as the one shown in the record of Belle Willis No. 2, 5 miles south-east from Friendly, in the Dye-Brooks oil pool, near Little's Mills on Middle Island creek, as follows:

Belle Willis Well No. 2, near Little's Mills, Tyler County.

On the farm of Belle Willis, Dye-Brooks oil pool, Middle Island creek, Tyler county. Authority, South Penn Oil Company.

		Feet.
Conductor	28 to	28
Unrecorded (10-inch-casing 149)	622 "	650
Sand (light show of oil)	... "	.....
Unrecorded	280 "	930
"*Cow Run*" *sand* (cased 8¼-inch at 916)	30 "	960
Unrecorded	136 "	1,096
"*Salt Sand*" (gas and water)	164 "	1,260
Unrecorded	230 "	1,490
"*Big Lime*" (*Mountain*)	60 "	1,550
Unrecorded ("*Keener*" *sand*)	31 "	1,581
"*Big Injun*" *sand*	79 "	1,660
Slate, black	20 "	1,680
Sand, white	20 "	1,700
Slate and shells	300 "	2,000
Sand, black	15 "	2,015
Slate and shells	165 "	2,180
Red rock	40 "	2,220
Limestone	10 "	2,230
Slate and shells	460 "	2,690

This is undoubtedly the *red* horizon which is so persistent, and lies between the "*Fifty-Foot*" *sand* and the "*Gordon*" *sand series* of Monongalia, Marion, Wetzel Harrison and Doddridge counties. Putting the top of the "*Big Injun*" sand at 1,550 feet in this record, the *red beds* would come 630 feet below that horizon.

The *Sistersville oil pool*, one of the largest and richest ever developed in the state was opened up by the Miller's Run Oil Company, which completed a well on the Stewart farm, opposite Sistersville, on June 26th, 1891. A hole had been sunk to the "*Big Injun*" *sand*, on the West Virginia side of the river, more than a year before at a locality known as the "Pole cat" well, but as salt water was present in great abundance no attempt was made to exhaust the same. When it was

later discovered that salt water was present with the oil in nearly all of the wells in the Sistersville pool, the old "Pole cat" well was operated and proved a large producer.

The Sistersville field occupies the crown of a broad low arch, where the relief is not sufficiently great to permit the separation of the large quantities of gas, oil and water that are present, and hence the three remain intermingled at every point in the field, except one or two small areas (and they are where the "*Big Injun*" lies highest) where gas alone is produced.

The production of the Sistersville pool (including the portion in Ohio) attained 20,000 barrels daily when at its height, which is probably twice the maximum production of any other pool yet found in the state.

The top of the "*Big Injun*" or producing sand at Sistersville lies 1,275–1,300 feet below the level of the Ohio river, and the *Pittsburg coal* horizon comes 135 to 150 feet under the river, thus making an interval of about 1,150 feet between these two important horizons, instead of 1,300 feet, as in eastern Tyler and Wetzel.

The *Pittsburg coal* being thin is often not observed by the drillers in the Sistersville region, but the Carter Oil Company reports it from the Ohio side, and one of these records from Mehrley No. 10, gives the following succession :

Mehrley Well No. 10, Opposite Sistersville, in Monroe Co., Ohio.

			Ft.	ct.
Unrecorded	175	to	175	
Coal (Washington)	3	"	178	
Unrecorded	407	"	585	
Coal, Pittsburg	5	"	590	
Unrecorded	430	"	1,020	

	Feet.
"*Cow Run*" *sand*	50 to 1,070
Unrecorded	55 " 1,125
Sand, *Freeport*	150 " 1,275
Unrecorded (contains "*Salt Sand*")	365 " 1,640
"*Big Lime*" (*Mountain*)	97 " 1,737
"*Big Injun*" { "break" ("*Keener*" *sand*) 15; sand, (oil, 1st "pay" 1,757) 63 }	78 " 1,815

This shows an interval of 1,147 feet between the *Pittsburg coal* and the "*Keener*" horizon of the "*Big Injun*" *sand*, or 1,162 feet to what is known as the "*Injun*," proper, in the Sistersville region.

Tyler county is crossed by a succession of anticlinal waves, and, therefore, is rich in oil pools, of which we have space to illustrate the stratification at only the most prominent ones.

The Keener Heirs' farm which gave the name to the "Keener" sand, lies 2½ miles south-west from Sistersville, and the structure there is illustrated by well No. 23, the record of which was received from the Carter Oil Company, as follows:

Keener Heirs Well No. 23.

	Feet.
Unrecorded	1,000 to 1,000
"*Cow Run*" *sand*	50 " 1,050
Unrecorded	100 " 1,150
Sand (*Freeport*)	150 " 1,300
Unrecorded	400 " 1,700
"*Big Lime* (*Mountain*)	40 " 1,740
"*Big Injun*" { "*Keener*" sand 30; "break" (slate) 15; sand, (1st "pay" 1805, 2nd "pay" 1835) 80 }	125 " 1,865

This record shows that the "*Keener*" sand horizon is simply the uppermost portion of the "*Big Injun*" formation, and corresponds to the first gas "pay" in

Marion and Monongalia counties, where there are frequently no slate "breaks" from top to bottom of this sand rock formation.

The *Kyle pool* of Tyler is on the waters of Indian creek, near the "*Big Moses*" gas well, one of the largest gas flows ever struck. The flames from this well when burning through 8¼-inch casing, ascended to a height of 173 feet, according to accurate measurements made by Mr. C. S. Lyon, the civil engineer of Sistersville. Mr. Browne of the Philadelphia Gas Company estimated its out-put at more than fifty million cubic feet daily, and this was the objective point of the great 16-inch gas line of that company which was extended from the Pennsylvania gas fields across Greene, Wetzel and Tyler counties, a distance of 60 miles. But before the connection could be made with the "*Big Moses*" *well*, on the Moses Spencer farm, 2 miles above the mouth of Indian creek, the *Kyle oil pool* had been opened near by in the same sand ("*Big Injun*") and the glory of the "*Big Moses*" had departed, not through *one* well but through *scores* of them. The stratification in the Kyle pool is given by Kyle well No. 2 of the Devonian Oil Company as follows:

Kyle Well No. 2.

	Feet.
Unrecorded (10-inch casing 265')	925 to 925
Gas *Keener* sand	25 " 950
Unrecorded (8¼-inch casing, 1,000')	50 " 1,000
Sand (*Fifty-foot*)	100 " 1,100
Unrecorded	535 " 1,635
Fourth sand (*Monterey*)	90 " 1,725
Unrecorded	53 " 1,778
"*Second*" (slate)	15 " 1,793
"*Big Injun*" sand (1st "pay" 1725-1811 ft.)	66 " 1,859

The top of the "*Big Injun*" really begins at 1725

feet in this record, but the driller has called it "*Big Injun*" only from the first oil horizon, 68 feet below the true top. The sand at 1000 feet he also calls the "*Salt Sand*," but this is an error, since the true "*Salt Sand*" of the *Pottsville series* belongs in the unrecorded interval of 535 feet below 1100 feet in depth.

In *the Wick pool* of Tyler, the succession is given by the Victor Oil Company at its No. 1 Stealey, as follows :

Stealey Well No. 1, near Wick, Tyler county.

	Feet.	
Unrecorded	180 to	180
Coal (*Washington*)	10 "	190
Unrecorded (10-inch casing 200 ft.)	835 "	1,025
Cow Run Sand	20 "	1,045
Unrecorded (8¼-inch casing 1100 ft.)	355 "	1,400
"*Salt Sand*"	160 "	1,560
Unrecorded (6¼-inch casing 1600)	175 "	1,635
Limestone (*Mountain*)	80 "	1,815
"*Big Injun*" { "break" ("*Keener*") 19 / sand [1st "pay" 1880-1905 ft.] 81 }	100 "	1,915

The *Pittsburg coal* horizon, if the bed were present, would come at about 625 feet in the above record.

The Hebron pool in south-western Tyler shows the following succession as given by the Fisher Oil Company at its No. 1 Barker well :

Barker Well No. 1, Hebron Region, Tyler County.

	Feet.	
Unrecorded	1,010 to	1,010
Cow Run Sand (8¼-inch casing 1,028 ft.)	18 "	1,028
Unrecorded (6¼-inch casing 1,793 ft.)	854 "	1,882
"*Big Injun*" *sand* ("pay" 1,926–1,942 ft.)	60 "	1,942

Hardman and Livingston No. 2, of the Carter Oil Company on Plum Run of McKim creek, in the Hebron region, gives a few more details of the stratification in the Hebron pool as follows :

Hardman & Livingston Well No. 2, Near Hebron.

		Feet.
Unrecorded	540 to	540
Coal (*Sewickley, Meigs creek*)	1 "	541
Unrecorded	559 "	1,100
Cow Run sand	32 "	1,132
Unrecorded	208 "	1,340
"*Salt Sand*" (in lower part)	300 "	1,640
Unrecorded	260 "	1,900
"*Big Lime*" (*Mountain*)	100 "	2,000
"*Big Injun*"..... sand "*Keener*"....42; "break"....3; sand (oil and gas 2,045 ft.)....35	80 "	2,080

The coal at 540 feet comes more than 100 feet above the horizon of the *Pittsburg bed*, and is probably identical with the *Sewickley coal* of Pennsylvania, or the *Meigs Creek seam* of Ohio.

The Elk Fork pool lies four miles north from Middlebourne and was very prolific in oil from the top of the "*Big Injun*" which may be the "*Keener*" horizon.

The stratification is given for that region by the following record of the William Ferrell well No. 2, drilled by the Henry Oil Company:

William Ferrell Well No. 2, Elk Fork Oil Pool.

		Feet.
Unrecorded	170 to	170
Coal (*Uniontown, Macksburg*)	4 "	174
Unrecorded (10-inch casing 180 ft.)	656 "	830
Cow Run sand (8¼-inch casing, 835 ft.)	25 "	855
Unrecorded	270 "	1,125
"*Salt Sand*"	250 "	1,375
Unrecorded	187 "	1,562
"*Big Lime*" (*Mountain*, cased 6¼-inch, 1,565 ft.)	68 "	1,630
"*Big Injun*" *sand* (oil 1,635)	8 "	1,638

This well starts about 30 feet under the *Washington coal*, and hence the place of the *Pittsburg bed* would be

found at about 425 feet. The coal bed at 170 feet is noted in nearly all of the Henry Oil Company's wells of this region, and the drillers term it the *"Pittsburg" bed*, but as it lies only 200 feet below the *Washington coal* which crops out at the surface and has been mined along Elk Fork, it cannot be the *Pittsburg* but must lie at least 250 feet above the horizon of the latter coal.

Many of the wells in the Elk Fork pool come in quite large, flowing at the rate of 50 to 60 barrels per hour.

The Conway oil pool is four miles further up Elk Fork creek, near Iuka P. O., and was opened by the Spragg Oil Company, of Wheeling, in 1896. The wells are not large and the oil is found deeper in the *"Big Injun"* than at Elk Fork village.

Before leaving Tyler a word must be said of the great salt water geyser which was struck on Middle Island creek, a few miles below Middlebourne. The next year after the Sistersville field was opened, a well was drilled into the *"Big Injun" sand* on Middle Island creek, reaching the same at a depth of 1,562 feet, and striking a vast pool of salt water which gushed forth in a constant stream to the height of 120 feet, at the rate of 16,000 barrels daily, as guaged by C. S. Lyon, the engineer. The flow continued for several months, but the well gradually weakened and finally produced five or six barrels of oil daily, along with salt water. The level of the derrick floor at the great salt water well is 668 feet above tide, or 83 feet higher than low water in the Ohio river at Sistersville, according to Mr. Lyon.

Going north up the Ohio river from Tyler county, the *"Big Injun" sand* dips down, and also thins away as a coarse, pebbly stratum, and with the exception of

some small wells drilled near the mouth of Proctor creek, no paying wells have been found in this sand along the Ohio river north from the Sistersville field.

Many wells have been drilled in Marshall county, but the only profitable oil pool yet discovered is in the vicinity of Moundsville. In 1886 a hole was drilled there by Mr. Joseph Craig of Pittsburg, on the Hicks farm, and a small well (5–6 barrels daily) was found in the "*Big Injun*" *sand* at a depth of 1,413 feet. Several other wells were sunk in the region, but none of them proved successful in the "*Big Injun*" horizon. One of these was drilled by the McCalmont Oil Company on the William Koontz farm, 3½ miles east from Moundsville, on the waters of Little Grave creek, and a very large flow of salt water was found in the "*Big Injun*" *sand* at a depth of 1,400 feet, the top of the sand being struck at 1,028 feet below the *Pittsburg coal.*

A very interesting "*shallow sand*" oil pool was discovered, three miles north-east from the *B.* & O. station at Moundsville in 1896, and the following record of a well drilled on the Gallagher farm on Middle Grave creek, one mile from Moundsville, will show the relations of the "*shallow sand*" to other important strata. The Survey is indebted to Hon. B. F. Meighen of Moundsville, for the record, and much other information concerning the pool in question. The record reads as follows:

Gallagher Well No. 1, Near Moundsville.

Authority, Dr. J. D. States.

		Feet.
Conductor	40 to	40
Limestone, hard	40 "	80
Coal, Sewickley	4 "	84
Limestone	72 "	156

		Feet
Coal, Pittsburg	6 to	162
Slate	72 "	234
Limestone	23 "	257
Slate (10-inch casing, 264 ft.)	92 "	349
Red rock	10 "	359
Slate and red rock	85 "	444
First Cow Run sand	20 "	464
Red rock	70 "	534
Sand	60 "	594
Slate, black	5 "	599
Coal	5 "	604
Shale, blue	175 "	779
Black slate and shells	163 "	942
"*Salt Sand*," *Pottsville*: sand 10; coal 3; sand 10; black slate and shells 31; sand, salt water 67	121 "	1,063
Slate and shells	82 "	1,145
"*Big Lime*" (*Mountain*), hard	85 "	1,230
Slate	25 "	1,255
"*Big Injun*" *sand*, salt water at 1275, gas at 1325	165 "	1,420
Slate to bottom	50 "	1,470

The producing sand in the "*shallow*" pool is the one at 444 feet in this record whose base comes 302 feet below the *Pittsburg coal*. The drillers call it the *First Cow Run sand*, and such it really seems to be, since the 70 feet of *red rock* under it puts it about the middle of the *Barrens*, and proves that it is not a member of the *Mahoning sandstone*, or *Dunkard sand series*. It is possible that this oil sand at 444 feet, 282 feet under the *Pittsburg coal*, may represent the *Morgantown sandstone*, but the top of that stratum is seldom more than 200 feet under the *Pittsburg bed*.

The top of the "*Big Injun*" *sand* is found here at only 1093 feet below the *Pittsburg coal*, this interval being 200 feet less than in the Piney fork oil field of Wetzel county, 30 miles south.

A record of one of the "*shallow sand*" producing

wells gives the following succession in Otto well No. 1, according to Mr. Johnson, the owner:

Otto Well No. 1, three miles north-east of Moundsville.

			Feet.
Unrecorded	185	to	185
Coal, Mapletown (*Sewickley*)	5	"	190
Unrecorded	82	"	272
Coal, Pittsburg	6	"	278
Unrecorded to bottom "pay" streak in *First Cow Run sand*	300	"	578

There are now (March 5th) about 30 wells producing from this sand and the yield is 100 barrels daily. The oil is peculiar in being lighter in gravity than any petroleum ever discovered, guaging 63°.5 B. after reaching the pipe line tanks. The only approach to this is the oil from probably the same sand in the Big Flint district of Doddridge county, which scaled 63° according to Mr. Wm. A. Earseman of the South Penn Oil Company.

At the southern end of Ohio county the succession of the rocks is shown by the deep well of the Wheeling Development Company on Boggs Run. The record preserved by Mr. J. C. Brady, the secretary of the company, from samples given him by the drillers, reads as follows:

Wheeling Development Company's Deep Well.

On Boggs Run, near Wheeling, as interpreted from samples of the drillings:

			Feet.
Unrecorded	275	to	275
Limestone and *coal* (*Sewickley*)	8	"	283
Limestone	32	"	315
Shale, gray	5	"	320
Limestone	4	"	324
Pittsburg coal	6	"	330
Gray sandy shale	30	"	360

		Feet.
Gray sand	8 to	368
Greenish gray slate	12 "	380
Red shale	30 "	410
Red and brown shale	34 "	444
Unrecorded	40 "	484
Gray sandy shale	6 "	490
Unrecorded	10 "	500
Red shale	250 "	750
Shale, red, *coal*, etc	110 "	860
Coal, Upper Freeport	4 "	864
Sandstone, gray	45 "	909
Coarse, gray sandstone	83 "	992
Fine white sandstone	408 "	1,400
Coarse, gray sandstone	60 "	1,460
Fine, white sandstone	90 "	1,550
Very hard white sandstone (base of "*Big Injun*")	20 "	1,570
Dark gray shale	330 "	1,900
Gray sandy shale	110 "	2,010
Gray and red shales	100 "	2,110
Gray and blue shales and sandy beds	350 "	2,460
Dark gray sandy beds	60 "	2,520
Gray sandy shells	180 "	2,700
Unrecorded	175 "	2,875
Light gray shale	80 "	2,955
Light gray sandy bed (slight show of oil)	40 "	2,995
Gray and dark shale	80 "	3,075
Gray sandy shale	125 "	3,200
Shale, gray	60 "	3,260
Shale, dark	80 "	3,340
Shale, dark gray	160 "	3,500
Shale, light gray	75 "	3,575
Shale, gray	375 "	3,950
Shale, soft, gray	50 "	4,000
Shales, dark, sandy, with an occasional shell to bottom	500 "	4,500

This is the well at which Dr. Hallock of Columbia University, New York, made very accurate and elaborate tests for temperature, and found that the bottom of the well had a temperature of 110°.3 F., while the top was 51°.3 F., thus giving a mean of 74.3 feet in depth for every increase of 1° F. in temperature, though in the lower half of the well the rate had increased to 1° F. for every 60 feet of depth.

The *Washington coal* crops at 40 feet above the level of the derrick floor, and we thus get 364 feet as the interval between these important "key" rocks instead of 460 feet at Pine Grove, Wetzel county, 25 miles south, and 540 feet at Mannington, still further (20 miles) to the south-east.

The Central Glass Company drilled a well near its factory in Wheeling, 3 miles north from the Boggs Run well, and the following record of the same was preserved by Hon. N. B. Scott, President of the Company:

Central Glass Works Well, Wheeliny.

		Feet.
Well begins 75 feet under *Pittsburg coal.*		
Interval from *Pittsburg coal*	75 to	75
Variegated shales with little sand	280 "	355
Coal	1 "	356
Sandstone, etc., not recorded	200 "	556
Coal (*Steubenville shaft coal*)	7 "	563
Sandstone and other rocks	96 "	659
Coal (one of the *Kittannings*)	5 "	664
Shells and hard gray sandstone	112 "	776
Sandstone, white, top of No. XII, (gas near bottom)	70 "	846
Sandstone, fine-grained, yellowish-gray, (oil at bottom)	50 "	896
Sandstone, coarse, hard, yellowish-gray, (oil and gas at 1000 ft, *Maxton*)	170 "	1,066
Sandstone, brown, coarse, ("*Big Injun*")	139 "	1,205
Shale, black	45 "	1,250
Sandstone ("*Squaw*" *sand*)	25 "	1,275
Unrecorded	330 "	1,605
Sandstone, fine-grained, brown, (*Berea Grit*)	10 "	1,615
Unrecorded to bottom, no definite sands	480 ',	2,095

A deep well was bored in Martin's Ferry, opposite the upper end of Wheeling, and the record of the same is given on page 405, Volume VI, of the Ohio Geological Survey, 1888. In this record two beds of *red shale* are reported, the first at 1,610 feet, about 1,700 feet below the *Pittsburg coal*, and the second one 50 feet

lower. These are evidently the *Catskill reds*, which separate the *Gantz* and *"Fifty-Foot" sand* horizons from the *Gordon group* below.

Passing on up the Ohio river into Brooke county, we find the following succession of the rocks at Wellsburg as given by the first gas well bored there on the W. C. Barclay land in 1882, the record of which was kept by Dr. E. E. Worthen, as follows:

W. C. Barclay Well No. 1, Wellsburg, Brooke County.

Near Wellsburg, Brooke county. Well mouth 40 feet above low water in Ohio river. Authority, Dr. E. E. Worthen.

		Feet.
Yellow clay.....20 Blue clay.....20 Gravel 32	Drive pipe (gas at 43)..... 72 to	72
Sandstone, blue.....	6 "	78
Slate, black (gas at 100 ft.).....	35 "	113
Fireclay	22 "	135
Sandstone, white.....	12 "	147
Fireclay	40 "	187
Slate	12 "	199
Coal, (Wellsburg shaft seam).....	5 "	204
Fireclay (cased 208 ft.).....	10 "	214
Slate (cased 225 ft.).....	20 "	234
Slate and shale.....	40 "	274
Sand, white (gas at 287 ft.).....	40 "	314
Slate and shale (cased 300 ft.).....	74 "	388
Sand (gas at 400 ft.).....	15 "	403
Slate and shale (cased 410 ft.).....	75 "	478
Pottsville "Salt Sand": sand, white, salt water, (gas at 535 ft.).....75 sand, gray.....30 sand, blue.....40 *coal* 6	.....151 "	629
Slate and shale.....	31 "	660
"Big Injun" sand, white (gas and salt water 750 feet., cased at 777 ft.).....	140 "	800
Slate and shale.....	50 "	850
"Squaw" sand, white (salt water 850 ft., gas at 857 ft.).....	50 "	900
Shale, blue.....	400 "	1,300
Sand, white, gas, *Berea (?)*.....	10 "	1,310

"At 1,310 feet struck big flow of gas so strong as to prevent further drilling."

This well begins on the first bottom of the Ohio river, 120 feet below the *Crinoidal Limestone*, and about 350 feet below the *Pittsburg coal* which crops in the highest summits, thus making the interval, 1,650 feet between the *Berea Gas sand* and that coal bed. At Washington, Pa., 30 miles east from here the interval between the *Pittsburg coal* and the *Gantz sand* is 1,800 feet.

The *Green Crinoidal Limestone* with its characteristic fossils crops out in the hills, at 120 feet above the level of the Barclay derrick floor, thus making an interval of 1,420 feet between this stratum and the *sand* of the gas well.

The *coal* at 199 feet is the same one formerly mined by a shaft at the foot of the hill near the Pan Handle R. R., in Wellsburg, where it lies 235 feet below the surface, and 320 feet below the *Crinoidal Limestone.* It is the same one mined by shafting at Steubenville, and is one of the *Freeport beds* of the Pennsylvania series.

Passing north into Hancock county, we find a considerable anticlinal arch, crossing the Ohio at New Cumberland. A well was bored for oil near the crest of this arch at New Cumberland in 1864, and struck a large supply of natural gas at about 600 feet below the level of the Ohio river. The product was utilized for several years in the manufacture of a fine quality of lamp-black for printing purposes, the jets of gas being forced to burn against metal troughs containing water, which chilled the flame and caused a deposit of carbon in the form of lamp-black. This well, though 35 years old, still continues to deliver a small quantity of gas to the Mack Manufacturing Company, the present owners, the gas being burned in several fires for office and

domestic use. This original well was quite large when first drilled, and after the use of gas for domestic and manufacturing purposes had become common in the '80's, other wells were drilled in the vicinity, but with very little success, since it was discovered that the one well had drained all of the surrounding region during the 20 years of its history, so that no other, except small gas wells, were found in the New Cumberland region.

The Turkey-Foot oil field begins about two miles east from New Cumberland, and was discovered about 1888. The stratification is given by the record of W. L. Crawford No. 2, drilled by the Fisher Oil Company, as follows:

W. L. Crawford Well No. 2, Turkey-Foot Oil Field.

		Feet.
Soil and clay	30 to	30
Sand	25 "	55
Slate (including a coal vein)	205 "	260
Sand	35 "	295
Slate and clay	60 "	355
Sand	45 "	400
Slate	60 "	460
Sand	15 "	475
Slate	30 "	505
Pottsville, No. XII, "Salt Sand": sand, salt water 110; slate 45; sand 25	180 "	685
Slate	35 "	720
"Big Injun" sand	95 "	815
Slate	350 "	1,165
Berea Grit, oil sand	19 "	1,184
Slate to bottom	14 "	1,198

In the Thomas Peterson well No. 2 of the Fisher Oil Company, the top of the *Berea* or oil sand was struck at 1167 feet, or 1222 feet below the *Green Crinoidal Limestone* which crops out along the bluff

55 feet above the derrick floor. This interval is 200 feet less than that between the same limestone and the gas sand at Wellsburg 20 miles south, and it is possible that the two sands represent a different horizon. *The Turkey-Foot oil sand* belongs about 900 feet below the *Upper Freeport coal*, and as this is the horizon of the *Smith's Ferry oil sand*, at the northern end of Hancock county, it is quite probable that the *Turkey-Foot sand*, and the *Smith's Ferry sand* are the same, whether they represent the *Berea* horizon or otherwise.

The Oil and Gas Horizons of West Virginia.

From these numerous well records given over a large region of the State, as well as the running commentary thereon, it will be perceived that there are several well defined oil and gas horizons between the *Permian* rocks at the top of the *Carboniferous*, and the *Carniferous Limestone* at the base of the *Devonian beds*. These may be grouped together and classified as follows, in descending order, together with the geological series in which they occur :

No. XV, Upper Coal Measures, Monongahela River Series.	*Carroll Sand.*
No. XIV, Barren Measures. Elk River Series.	*Island RunSand, (Morgantown.)* *First Cow Run Sand,* *Upper and Lower Dunkard Sands.*
No. XIII, Lower Coal Measures Allegheny River Series,	*Second Cow Run Sand,* *"Gas" Sand of Marion and Monongalia Counties.*
No. XII, Pottsville Conglomerate beds, New River and Pocahontas Coal Series.	*"Gas" Sand of Cairo,* *"Salt Sand"* *Maxton and Cairo oil sands.*
No. XI, Mauch Chunk Red Shale	*No oil or gas sands unless the Maxton Sand belongs here.*
No. XI, Mountain or Greenbrier Limestone,	*No oil or gas horizons except as part of the "Big Injun" below.*
No. X. Pocono Sandstone.	*"Keener" Sand,* *"Big Injun" Sand,* *"Squaw" Sand.*

No. IX. Catskill Red Beds, Upper Devonian Series, Venango Oil Sand Group.	*Gantz Sand (Berea Grit), Fifty-Foot Sand, Thirty-Foot Sand, Campbell's Run "Gordon" Sand, Whetstone Run "Gordon" Sand, Flat Run "Gordon" or Fourth Sand, McDonald or Fifth Sand*
	Elizabeth or Sixth Sand.
No. VIII, Chemung, Hamilton and Corniferous Beds, Middle and Lower Devonian.	*No well defined oil or gas horizons yet discovered in these rocks in West Virginia. Warren and Bradford Sands of Pennsylvania supposed to belong in upper portion.*

The Elizabeth or Sixth Sand is placed alone between the *Catskill red beds* and the *Chemung*, proper, because it is uncertain to which series it belongs. It was not in the original *Venango Group* of Prof. John F. Carll, as it underlies the *Venango beds* by 150 to 200 feet, and hence cannot be included therein. Mr. Carll thinks it is a "split" from the old *Venango Third Oil Sand*, but as yet there is no positive evidence to sustain that hypothesis, and since no *red beds* have been encountered *under* this sand, it is placed on the dividing line between the *Catskill red rocks* and the *Chemung gray beds*, below.

This *Elizabeth (Sixth) Sand* is then the lowest known oil and gas bearing rock yet discovered in West Virginia. Whether any of the rocks below it will ever produce oil or gas in profitable quantity within the State is a problem for future operators to determine.

In the adjoining State (Ohio), about 300 miles distant from the West Virginia border, the *Trenton Limestone* of the *Lower Silurian* has proven very rich in both oil and gas, while in the Sugar Grove region of Ohio, only 60 miles north from the West Virginia line on the Ohio river, the *Medina* or *Clinton beds* of the *Upper Silurian* have yielded a wonderful supply of high pressure natural gas to the cities of Columbus,

Zanesville, Logan, Lancaster, Nellsonville, etc. In New York, Dr. Orton reports the finding of very high pressure gas wells in the *Potsdam Sandstone*, at the very base of the *Palaeozoic column*, and only a few feet above the primitive granite.

It was formerly supposed that no oil or gas in commercial quantity would be found in rocks below the *Cattskill series* of the *Devonian*, but as that belief has now been completely overthrown by the results of the drill, and as both theory (anticlinal) and facts of the present, unite in proving that the only conditions necessary for the accumulation of large quantities of gas or oil, are porous, stratified rocks, thrown into waves of considerable but not too violent relief, with a cover sufficiently impermeable to prevent escape, there remains no sound reason why there may not be other oil and gas reservoirs under the surface of West Virginia, far below the *Sixth*, or *Elizabeth Sand*.

It is true, that except in the south-western part of the State, say from the Little Kanawha river, westward, it would probably be impossible at the present stage of the deep drilling art, to reach any of these horizons even in the *Upper Silurian*, (*Medina*) but this may be possible, and even profitable some time in the future. To reach the Medina horizon, anywhere in the Monongalia, Marion, Wetzel. Tyler or Doddridge county oil fields, would require a boring probably not less than a mile and a half in depth, and the *Trenton horizon* would then be possibly a half-mile further below. But in the region of Huntington, the *Corniferous Limestone* which lies 600 to 800 feet above the Medina, was struck at only 2760 feet, and hence in that portion of the State where the *Catskill, Che-*

munq and *Hamilton beds* have *thinned away* so greatly, it will be quite easy to bore to the *Medina gas horizon*, and even possible to reach the *Trenton*, though owing to the absence of the proper *relief* or *structural features*, it is doubtful if either would be found gas or oil bearing in that region.

As stated on a preceding page, the *mountain regions* of the State have not been properly tested for the presence of gas or oil, since from the great size of the anticlinal arches in those regions, and the necessary fracturing, and fissuring of the rocks resulting from these steeply folded strata, any borings must necessarily go to a great depth (5,000–10,000 feet) in order to give a fair test under such conditions.

Upon the theory of the origin of natural gas and petroleum from buried organisms (both animals and plants,) and there are but few geologists who advocate any other, it would appear entirely reasonable to believe that enough organic matter has been entombed in any of the earth's stratified, or sedimentary beds, to furnish large supplies of the hydro-carbon compounds, in the form of either oil or gas, or both, provided the small quantities of each in any of such strata, can find a *porous reservoir* in which to collect, and a *geological structure* (the rocks disturbed by *anticlinal waves*, or rapid and irregular dips) favorable to the seggregation and preservation of the same. Of course if the rocks be highly contorted, fractured, faulted, or too greatly disturbed, all of these hydro-carbons within reach of ordinary drilling operations will have escaped from the strata and it will prove useless to explore for them, even in sedimentary beds, and it goes without saying that no stores of either oil or gas need be looked for in

crystalline or metamorphic rocks of any description, such as granites, syenites, schists, etc.

Character and Quality of West Virginia Petroleum.

All of the oil produced in the State belongs to the highest grade and quality of Pennsylvania petroleum of the "white sand" type. It has a parraffine base instead of asphalt as in Russian and most foreign oils, as well as in that from California, Wyoming, Colorado, Texas, and all regions yielding petroleum from rocks of recent geological age, since the paraffine oils appear to be confined almost exclusively to rocks of the *Palæozoic Era.*

The color of the West Virginia petroleum ranges from almost black through all shades of green and amber up to a nearly transparent fluid with only a tinge of yellow, while the gravity varies from 28° B., a good quality of lubricating oil, occurring in the "*Salt Sand*" of the Volcano region, Ritchie county, at a shallow depth, to 63½° B., the lightest gravity petroleum known in the world, found in the *First Cow Run Sand*, near Moundsville, Marshall county.

Mr. H. L. Scrafford, General Manager of the Eureka Pipe Lines in West Virginia, has kindly given me a statement of the gravity, color, etc., of the oils from the different sands in West Virginia, and the adjoining region of south-eastern Ohio, as handled by the pump stations in the several regions. These oils would show a little higher gravity if the samples had been taken direct from the wells, but those given are the gravities of the several oils after they had been transported to the different local pumping stations, and hence represent them on a commercial basis. This table which

often includes several samples in the same region is as follows :

Location of Pump Station.	County.	Sand.	Gravity. °'s B.	Color.
Mt. Morris	Greene, Pa.	Big Injun	46	Amber
" "	" "	Dunkard	42	"
" "	" "	Elizabeth, Sixth	41	"
Dolls Run	Monongalia	Big Injun	46	"
Jakes Run	"	" "	46	"
Basnett, Fairview,	Marion	Gordon	43½	"
" "	"	Big Injun	45¾	"
Downs. Mann'gton	"	Gordon	42¾ to43½	"
" "	"	Big Injun	46½	"
Tetrich	"	Gordon	42½	"
Joetown	"	"	42¾	"
Masters, Board Tree	Greene, Pa.	"	42½	"
Glendale	Marshall	First Cow Run	63½	"
Arches	Wetzel	Dunkard	52½	"
"	"	Big Injun	45¾	"
"	"	" "	46½	"
"	"	" "	48¼	"
"	"	Gordon	39¼	"
"	"	"	42¼	"
Richwood	"	"	43¾	"
Pine Fork	"	"	44¼	"
Braden, Indian Cr.	Tyler	Big Injun	47¼	"
" "	"	Gordon	44¼	"
Big Flint	Doddridge	Dunkard	48¼	Black
" "	"	Maxton	45	Amber
" "	"	Big Injun	42¼	Black
" "	"	" "	43¾	"
" "	"	" "	45½	Amber
" "	"	" "	46½	"
" "	"	" "	47½	"
" "	"	Gordon	42	"
" "	"	"	43¾	"
" "	"	"	48¾	"
" "	Harrison	Fifth, McDonald	44	"
Ankrom, Indian Cr.	Tyler	Maxton	45½	"
" " "	"	Big Injun	48	"
" " "	"	" "	46½	Black
Martin, Elk Fork	"	Keener	49¾	Amber
Sancho (Bradens)	"	Maxton	43	Black
" "	"	Big Injun	50	Amber
Wick	"	Cow Run	47	Green
"	"	Maxton	47	Black
"	"	Keener	45	Amber
"	"	Big Injun	52	"
Hebron	"	Cow Run	46	Green
"	"	Big Injun	46¾	Amber
Stewart, Mid'eIslCr	"	Cow Run	54	"
" " " "	"	Maxton	44	Black
" " " "	"	Keener	53¾	Amber
" " " "	"	Big Injun	44½	"
" " " "	"	" "	46¾	Green
" " " "	"	" "	54	Black

Location of Pump Station	County.	Sand.	Gravity, °'s B.	Color.
Thistle, Sisterville	Tyler	Keener	48	Amber
" "	"	"	47	"
"	Monroe, O.	"	47¾	"
"	"	Salt Sand	44	"
"	"	Big Injun	47½	"
"	"	" "	50	"
"	"	" "	50½	"
"	"	Maxton	47	Black
"	"	Berea	46½	Amber
Trail Run	Washington, O.	Keener	44½	"
" "	"	"	46	"
" "	"	"	46¾	"
" "	"	Big Injun	47	"
" "	"	" "	48	"
" "	"	" "	49	"
Cairo	Ritchie	Salt Sand	45½	"
"	"	Big Injun	50	"
Pennsboro	"	Boulder	41	"
Burning Springs	Wirt	Cow Run	39	Green
" "	"	Big Injun	51	"
Volcano	Wood	Salt Sand	34½	"
"	"	Berea	50½	"
Mounts, Stillw'l Cr.	"	"	41	"
Boreman, Worthington Creek	"	"	39½	"
Big Run	"	Cow Run	43	"
Bull Cr. Waverly	"	" "	46	"
" " "	"	Big Injun	40	"
Eureka	Pleasants	Cow Run	46	"
"	"	Berea	51	"
"	Washington, O.	Shallow	42	"
"	"	First Cow Run	49	"
"	"	" " "	50½	Lig't Green
"	"	Second " "	43½	Dark "
"	"	Salt Sand	42	" "
"	"	Big Injun	42	Green
"	"	" "	53¼	Amber
"	"	Berea	41	Green
"	"	"	47½	Amber
Corning	Athens, O.	"	38	Black
New Castle	Monroe, O.	"	43	"
Barnesville	Belmont, O.	"	44	"

It was the intention of the State Geologist to give a special description of each producing sand, its character, distribution, etc., but the limited financial resources of the survey compel the abandonment of that subject, as well as the discussion of many others pertaining to the origin and distribution of petroleum,

hence this volume must be closed with a short reference to what might be called

"*The Gordon Sand Group.*"

By reference to the type section of the Pennsylvania oil sand series, (pages 214–226 of this volume), it will be perceived that the top of the true "*Thirty-Foot*" *sand* is there found at 2005 feet below the *Pittsburg coal*, and that coming next in order below is the *Gordon sand* with a thickness of 60 feet, and then the *Fourth sand* extending to 2180 feet below the *Pittsburg coal*, thus making a *sand group* 175 feet thick from the top of the "*Thirty-Foot*" to the bottom of the *Fourth sand*, or 240 feet thick if we include the *Fifth sand* to 2245 feet under the *Pittsburg coal*.

Now in Marion and Monongalia counties, West Virginia, the name "*Gordon*" in some form or other has been applied by the oil fraternity to at least *four* distinct horizons in this series of sands from the "*Thirty-Foot*" down to and including the *Fourth*.

Near Washington, Pennsylvania, on the Gordon farm, from which the sand in question takes its name, the top of the producing rock is found at 2100 feet below the *Pittsburg coal*, and it is believed that this interval increases slightly to the south, and that thus the true *Gordon sand* becomes the *Campbell's Run sand* of Marion and Monongalia counties, and the great *deep sand oil horizon* of Wetzel, Tyler and Doddridge counties, while the "*Gordon Stray*," just above, belongs to the "*Thirty-Foot*" horizon of the Pennsylvania section, and is the *gas horizon* par excellence of the *deep sand* series.

The *Whetstone Run* "*Gordon*" sand is a division of

that series, next under the *Campbell's Run bed,* and the *Flat Run "Gordon"* appears to correspond to the *Fourth sand* of the Pennsylvania series.

The *producing oil rock* near Jarvisville at 2310 feet below the *Pittsbury coal* has been provisionally identified with the *Fifth* or *McDonald sand* of the Pennsylvania series, but it may turn out to be the *Elizabeth* or *Sixth sand,* the same as the *Bayard gas sand* of Greene county, and the one that produces oil on the Shriver farm, Dunkard creek, Monongalia county, near the Pennsylvania line, at 2408 feet below the *Pittsburg coal,* (see pages 236-7).

If this conclusion is correct, viz, that the oil and gas production from the *deep sands* of Wetzel, Tyler, and western Marion and Monongalia, is really from the top members of a sand series which in Pennsylvania has a thickness of 240 feet, then it is reasonable to expect that some of the lower members of this series will yet be found productive in many regions of these counties in question where no tests for their presence have yet been made.

As a general rule, (though there are many exceptions to it), good, paying oil sands are not found directly under those already producing, so that it is better when making tests for lower sands, to select contiguous regions where the upper ones are unproductive.

Appendix to Part II.

Levels Above Tide.

The elevation and distance tables on some of the Railroads of the state, and also on some of the rivers, were not received in time to be included in the regular place for them in Part II, and these are now added here, thus making a very complete publication of the profiles which cover nearly every portion of the state, not only on the railroads actually built, but also on some that are only projected. The river surveys added will also prove of much value and interest.

Dry Fork Railroad.

HENDRICKS, W. VA., January 30th, 1899.

DR. I. C. WHITE,
State Geologist,
MORGANTOWN, WEST VA.,

DEAR SIR:—I herewith enclose table showing distances from Hendricks, (which is our junction with W. Va. C. & P. Ry.), elevations, using W. Va.

Central and Pittsburg Ry., datum of 1702.1 feet for Hendricks, and elevation of water in Dry Fork River, using same datum. The distances given are correct, the road having been recently measured. I cannot, however, say that the elevations are absolutely accurate, they having been taken from the location notes. I believe, though, that there are no errors greater than a foot or two, at the outside.

Very truly yours,
F. K. BRETZ,
General Manager.

Distance.	Stations.	State.	County.	Elevations.	
				Grade	Low wat'r
0.0	Hendricks	W.Va.	Tucker	1702.1	1690.1
3.06	Red Run	.....	.....	1804.1	1795.1
6.19	Rich Ford	.....	.....	1864.1	1843.1
7.47	Mill Run	.....	.....	1890.1	1880.1
8.32	Elk Lick	.....	.....	1912.1	1900.1
9.07	Gladwin, (old station)	.....	.....	1951.1	1940.1
12.06	Flynn's Crossing	.....	.....	2019.1	2011.1
13.50	Mouth Laurel Fork	.....	.....	2051.1	2039.1
14.59	Carr's	.....	.....	2072.1	2066.1
17.50	Dry Fork	.....	Randolph	2177.1	2170.1
21.13	Harman	.....	.....	2334.1	2327.1
24.78	Lower Dam	.....	.....	2497.1	2492.1
26.14	Job	.....	.....	2578.1	2572.1
28.72	Gandy	.....	.....	2657.1	2652.1
30.66	Whitmer C.L.B.&L.Co.	.....	.....	2757.1	2750.1
31.25	Horton "	.....	.....	2805.1	2799.1

Guyandot Valley Railway.

HUNTINGTON, W. VA., February 20th, 1899.

DR. I. C. WHITE,
State Geologist,
MORGANTOWN, W. VA.,

DEAR SIR:—I have your letter of the 15th requesting distances and elevations on the proposed line of the Guyandot Valley Railway Company. I enclose the same from our survey profile, the figures being based upon the elevations at C. & O. R. R. Bridge over Guyandot River in Huntington, W. Va., which is about 550 ft.* We have no survey above Pineville or Rock Castle except a preliminary survey for about ten miles up the main Guyandot which shows an elevation of about ten feet to the mile. Trusting the accompanying information will be what you want, I am

Yours truly, J. L. CALDWELL.

Distance.	Stations.	State.	County.	Elevations.
0.00	Huntington (C.&O.R.R. Bd'ge)	W.Va.	Cabell	550
8.00	Mouth of Davis Creek	.....	.....	550
14.00	Mouth of Merritt Creek	.....	.....	545
20.50	Mouth of Madison Creek	.....	.....	558
25.75	Mouth of One-Mile Creek	.....	Lincoln	570
31.00	Mouth of Six-Mile Creek	.....	.....	585
35.25	Mouth of Laurel Creek	.....	.....	590
42.25	Mouth of Big Ugly Creek	.....	.....	595
52.50	Mouth of Green Shoals Creek	.....	.....	620
60.00	Chapmanville	.....	Logan	630
71.00	Logan Court House	.....	.....	665
80.50	Mouth of Rich Creek	.....	.....	715
85.00	Mouth of Rock House Creek	.....	.....	735
90.00	Mouth of Elk Creek	.....	.....	760
97.00	Mouth of Gilbert Creek	.....	.....	830
101.75	Mouth of Cub Creek	.....	Wyoming	870
104.00	Mouth of Leatherwood Creek	.....	.....	955
112.00	Mouth of Clear Fork Guyandot	.....	.....	1110
123.00	Mouth of Turkey Creek	.....	.....	1175
130.50	Mouth of Rockcastle Creek (Pineville)	.....	.....	1275

*Guyandotte station on C. & O. R. R. near bridge is 560. (I. C. W.)

Charleston, Clendennin & Sutton Railroad.

CHARLESTON, W. VA., February 24th, 1899.

DR. I. C. WHITE,
State Geologist,
MORGANTOWN, W. VA.

DEAR SIR:—Complying with your request of November 21st, 1898, which request was referred to our Philadelphia office, I have the pleasure to furnish you the following list of stations on our road between Charleston and Clay Court House, together with the elevation above tide, of the top of the rail in front of each station, showing also the distance in miles and tenths of miles of each station from Charleston.

Our railroad is only completed to Clay Court Honse, but our surveys and location extend to Sutton. Over this portion I add the distances from Charleston and the tide elevation of proposed grade of top of rail at several streams which are crossed by the proposed extension.

The elevation of our grade at all the points mentioned is a little above the ordinary Elk River bottoms.

I trust that this information will reach you in time for your publication.

Yours truly,

CHAS. K. MCDERMOTT,
Superintendent.

Distance.	Stations.	State.	County.	Elevation. Top of rail.
0.0	Charleston	W. Va.	Kanawha.	597.13
1.5	Two Mile	.....	.....	597.33
2.5	Wilson	.....	.....	600.83
3.8	Barlow	.....	.....	604.93
6.0	Mill Creek	.....	.....	602.83
7.3	Masons	.....	.....	606.83
8.5	Indian Creek	.....	.....	608.83
10.0	Pinch	.....	.....	608.83
11.0	Jarrett's Ford	.....	.....	615.83
13.0	Blue Creek	.....	.....	613.83
14.6	Walnut Grove	.....	.....	614.83
15.8	Rich Creek	.....	.....	617.83
17.0	Falling Rock	.....	.....	617.33
18.6	Reamer	.....	.....	623.73
20.5	Clendennin	.....	.....	624.43
22 7	Morris Creek	.....	.....	633.23
23.3	Blyth	.....	.....	635.89
24.4	Queen Shoals	.....	.....	637.55
27.6	Porter's	.....	Clay	643.83
28.9	Rand	.....	.....	645.83
30.3	King	.....	.....	650.83
31.8	Camp	.....	.....	651.33
32.7	Dulls	.....	.....	652.83
35 9	Shelly Junction	.....	.....	662.83
38.4	Birch	.....	.....	668.73
39.5	Little Sycamore	.....	.....	671.83
41.1	Big Sycamore	.....	.....	673.83
42.9	Pierson	.....	.....	677.83
44.2	Little Beechey	.....	.....	682.33
44.6	Yankee Dam	.....	.....	684.43
46.4	Big Beechey	.....	.....	693.93
47.2	Middle Creek	.....	.....	698.43
48.1	Upper Leatherwood	.....	.....	700.83
50.8	Clay Court House	.....	.....	706.03
51.9	Buffalo Creek	.....	.....	711.33
70.7	Grove's Creek	.....	.....	785.83
77.0	Strange Creek	.....	Braxton	805.83
79.2	Birch River	.....	.....	808.83
80.9	Fording Run	.....	.....	813.83
81.8	Upper Mill Creek	.....	.....	813.83
87.6	Raccoon Creek	.....	.....	827.13
93.8	Bear Creek	.....	.....	840.23
94.2	Little Buffalo Creek	.....	.....	840.83
97.6	Big Buffalo Creek	.....	.....	840.83
97.9	Scidmore's Run	.....	.....	844.23
98.1	Opposite Sutton Bridge	.....	.....	844.93
98.7	Buckeye Creek	.....	.....	846.33
	High water at Sutton, 1861	.....	.....	840.10
	" " " " 1875	.....	.....	837.30

Monongahela River.

PITTSBURG, PA., February 1, 1899,
OFFICE U. S. ENGINEERS.

DR. I. C. WHITE,
State Geologist,
MORGANTOWN, W. Va.

DEAR SIR :—Referring to your request of the 24th ultimo, I here enclose list of benches and level points along the Monongahela river from Pittsburg to dam No. 9, and the same along the West Fork from near its mouth to Clarksburg.

The elevation of the lower sill masonry, lock No. 10, is to be 786.92 and top of lock walls 813.17 feet.

From dam No. 9 to Hoults, the list of benches etc., is given in the Annual Report of the C. of E., 1897, page 2407, a copy of which is at the Morgantown office, which list Mr. Lucas will copy for you, and furnish, as far as he is able, the distances from dam No. 9. From Hoults to bench No. 12, West Fork river, the list is given on page 2182 of my annual report for 1898, a copy of which is mailed you to-day. Mr. Lucas may be able to furnish the distances of these benches from dam No. 9.

Very respectfully,
CHAS. F. POWELL,
Major Corps of Engineers.

Elevation of Points along the Monongahela River, Referred to mean tide level at Sandy Hook, N. J., per P. R. R. levels.

*Distance from mouth of river. Miles.	Elevation Feet.	Stations.
0.0	703.00	Pittsburg,—Harbor level, full pool, Davis Island Dam.
1.95	707.40	Crest of Dam No. 1, B. M. north side 2nd Ave. at angle between retaining wall and abutment of B. &. O. new bridge over 2nd Ave., on first course masonry above ground
1.95	693.50	Lower sill, large lock, Elevation 730.46 A. T.
11.76	715.10	Crest of Dam No. 2, B. M., N. W. corner bridge seat, south abutment, west side. Elevation, 732.392 A.
11.76	701.30	Lower sill, large lock, T.

*A close approximation.

Distance from mouth of river. Miles.	Elevation. Feet.	Station.
24.90	723.10	Crest of dam No. 3, B. M., Stone buried 1 ft. between rails north bound track P. R. R. point of curve (glass works) nearly opposite abutment of dam No. 3. Elevation 750.448 A. T.
24.90	709.46	Lower sill, large lock
41.33	733.48	Crest of dam No. 4. B. M., Stone buried 1 ft. between rails main track P. R. R., about 100′ below lock No. 4, station building. Elevation 759.516 A. T.
41.33	718.03	Lower sill, large lock
59.45	746.41	Crest of dam No. 5.
	730.28	Lower sill of lock.
69.25	760.15	Crest of dam No. 6. Elevations between locks Nos. 4, and 9 not verified.
	742.84	Lower sill of lock.
83.90	769.90	Crest of dam No. 7.
	754.19	Lower sill of lock.
88.90	780.80	Crest of dam No. 8.
	765.00	Lower sill of lock.
94.20	793.40	Crest of dam No. 9. Established from R. R. surveys brought from Uniontown, Pa.
	775.55	Lower sill of lock.
	787.00	Upper miter sill.
*102.70	820.601	Eye of ring bolt, north end of Morgantown Suspension Bridge abutment, right bank.
	821.867	North corner, north abutment, railroad bridge, Decker's creek. B. M. cut.
103.45	804.695	Railroad spike in sycamore, left bank, about 1,200 feet above the Morgantown Suspension bridge.
104.20	822.130	North corner, north abutment, railroad bridge, Cobun's creek. B. M., cut.
	816.249	North end of door sill, boiler house of pump station, Eureka Pipe Line Co.
105.70	813.152	Railroad spike in walnut, right bank, lock No. 11.
	830.575	Spike in locust, left bank, lock No. 11.
105.95	828.852	North corner, north-east abutment, railroad bridge Booth's creek. B. M., cut.
107.45	843.139	Railroad spike in beech above railroad near railroad culvert, lower end of Round Bottom.
110.45	834.606	Railroad spike in walnut (now stump) near residence of J. D. Summers, right bank.
110.70	839.365	Railroad spike in locust, right bank, just above dam No. 12.
	821.455	Spike in hickory, left bank, just below lock No. 12.
	849.258	Railroad spike in chestnut, left bank, near line of axis of dam No. 12, original location.
	849.845	Railroad spike in chestnut, near line of axis of dam No. 12, final location. Left bank.

*Levels from Lock No. 9 to Clarksburg were furnished by J. N. Lucus, Sub-Inspector U. S. Engineer Corps.

Distance from mouth of river. Miles.	Elevation. Feet.	Station.
	852.051	Railroad spike in locust in bottom, left side of river, lock No. 12.
111.45	846.129	North corner, north-east abutment, railroad bridge, Tom's Run. B. M., cut.
112.20	851.417	North-east corner, east abutment, railroad bridge, Joe's Run. B. M., cut.
112.45	857.352	Point on rock ledge above railroad, right bank, upper end of railroad rock cut just below dam No. 13. B. M., cut.
	832.143	Railroad spike in oak, left bank, lock No. 13.
	846.308	Railroad spike in apple tree, left side of river, lock No. 13.
112.70	848.470	Railroad spike in chestnut, right bank, Trippett's Ripple.
114.70	859.152	Railroad spike in locust, right bank, near brick house, below Big Falls.
117.20	837.780	Point on flat rock, left shore, lock No. 14. B.M., cut.
	835.875	Railroad spike in sycamore, right shore, lock No. 14.
	858.827	Spike in apple tree in John Hood's orchard, lock No. 14, left side of river.
117.45	863.515	North corner, north-east abutment, railroad bridge, White Day creek. B. M., cut.
119.95	875.741	Railroad spike in locust near residence of A. B. Jolliffe, right side of river.
120.95	868.385	North corner, north-east abutment, railroad bridge, Little Creek. B. M., cut.
121.20	879.747	Railroad spike in walnut, upper end of railroad cut, above Catawba station.
121.95	873.567	East corner, south-east abutment, railroad bridge, Prickett's Creek. B. M., cut.
123.20	875.665	Southwest corner of stone foundation of brick warehouse, Montana.
123.70	879.279	Railroad spike in gum, right bank, Rivesville Station.
124.70	861.206	Railroad spike in hickory, right bank, near residence of Ira Fleming, deceased, lower site for lock No. 15.
	851.277	Railroad spike in sycamore, left bank, mouth of Hockinberry Hollow.
124.95	882.433	Railroad spike in sugar tree, right bank. above railroad, near vacant house.
125.20	856.516	Railroad spike in oak, right bank, Pitcher's Ripple.
	866.940	Railroad spike in sugar tree, left bank, Pitcher's Ripple.
125.70	859.589	Railroad spike in sycamore, right bank, Hoult's Mill, upper site for lock No. 15.
	859.153	Railroad spike in swamp oak, left bank, opposite Hoult's Mill, upper site for lock No. 15.
127.20	885.474	North-east corner center pier, B. & O. R. R. bridge across river below Fairmont.

Distance from mouth of river. Miles.	Elevation. Feet.	Station.
128.45	899.681	Southwest corner, bridge seat of abutment, Fairmont Suspension Bridge, Fairmont end.
129.95	886.593	Extreme south-west, or upper corner, north abutment, B. & O. railroad bridge across river above Fairmont.
130.25	882.516	East corner, north abutment, New England railroad bridge. B. M., cut.
	880.083	Bottom of New England railroad bridge.
130.65	887.728	Highest point on lower wall of abutment, Honsacker bridge, left side of river. B. M., cut.
	884.479	Bottom of Honsacker bridge.
131.15	868.719	Railroad spike in walnut below railroad, left bank, upper end of coke ovens, Watson Mines.
131.55	885.630	Railroad spike in sycamore above railroad, Gaston station.
.....	887.673	South-east corner, center pier, Monongahela River Railroad bridge. B. M., cut. Bottom of bridge same elevation.
132.55	884.746	Railroad spike in chestnut about one-fourth mile above Thompson, right bank, below railroad.
.....	885.350	Point on upper wall, railroad culvert, lower end of railroad curve and cut near below White Rock. B. M., cut.
134.25	859.686	Railroad spike in sycamore, head of ripple below Monongah, right shore.
134.75	884.680	South corner, north-east pier, railroad bridge, Booth's creek, Monongah. B. M., cut.
134.85	883.387	R. R. spike in large willow, lower side of public road about 1,000 feet down stream from Monongah coal tipple No. 3.
135.15	873.386	R. R. spike in Buckeye tree, between R. R. and river, lower edge of public road, about 230 feet up-stream from Monongah Coal Tipple No. 3.
135.55	900.238	Point on rock ledge above R. R., 8 feet from center of main track and about 870 feet up stream from mile post No. 7, and about 750 ft. down stream from J. A. Clark Coal Tipple. B. M., cut.
135.85	893.568	R. R. spike in sugar tree, between R. R. and river near crossing of R. R. and public road and about 420 feet down stream from Bryan & Loller Coal Tipple.
136.15	895.724	R. R. spike in dead chestnut near Righter's Mill.
136.55	890.999	R. R. spike in oak between R. R. and river, at upper end of long straight R. R. track and 840 feet down stream from mouth of Koon's run.
137.05	875.969	R. R. spike in large elm between R. R. and river and about 570 ft. down stream from tipple of Clark C. & C. Co.

Distance from mouth of river. Miles.	Elevation. Feet.	Station.
137.65	883.693	R. R. spike in large black walnut between R. R. and river, opposite new coal opening of the Monongah C. & C. Co. (Middleton tipple) in bend of river about ¾ mile below Chiefton.
138.15	894.853	Point on masonry of railroad culvert, upper side of track, 1200 ft. below Clark C. & C. Co. tipple, Chiefton. B. M., cut.
138.55	897.740	R. R. spike in large hickory tree between R. R. and river and about 780 ft. up stream from Chiefton R. R. station.
139.45	874.499	Seat for rod cut in upper wall of abutment of bridge across river at Worthington, 25 ft. back from face of abutment and 2½ ft. above surface of ground, left side of river. B. M., cut.
139.65	893.323	Point on lower or river end of R. R. stone culvert, Worthington station. B. M., cut.
140.05	883.458	R. R. spike in small forked ash, 1800 ft. down stream from tipple No. 1 of Worthington C. & C. Co.
140.35	896.242	R. R. spike in large oak, 300 ft. down stream from tipple No. 1 of Worthington C. & C. Co., between R. R. and river.
140.95	894.395	Point on masonry, lower or river end of R. R. culvert 2500 ft. up stream from tipple No. 1 of Worthington C. & C. Co.
141.35	886.323	R. R. spike in forked sycamore opposite mouth of Bingamon creek.
142.05	904.464	Point on north corner east pier Enterprise highway bridge. B. M., cut.
142.45	909 094	Point on rock ledge, above R. R., 10 feet from center of track, lower end of railroad switch, about 645 feet down stream from tipple of Worthington C. & C. Co. No. 2. B. M., cut.
142.75	895.071	Point on north corner lower or river end of railroad stone culvert, Harrison's Run. B. M., cut.
143.35	893.030	Point on lower or river end of railroad stone culvert, opposite dairy farm of Wm. Hood.
143.85	885.765	Railroad spike in small water elm, at mouth of small ravine 2260 ft. up stream from Mud Lick Run.
144.15	911.213	Railroad spike in large forked chestnut between railroad and river near mouth of run, 1950 ft. down stream from Shinnston railroad station.
144.65	911.566	North corner, east abutment, Shinnston Highway bridge. B. M., cut.
145.25	907.231	Railroad spike in large chestnut near mouth of run, 1700 ft up stream from mouth of Shinn's run.

Distance from mouth of river. Miles.	Elevation. Feet.	Station.
145.75	892.555	Railroad spike in hickory at foot of river bank between railroad and river, about 240 ft. up stream from mile post 17.
146.15	895.301	Railroad spike in large forked elm near mouth of "Nigger" run.
146.65	899.523	Railroad spike in water elm, 800 ft. down stream from Robinson's run.
147.15	916.219	Railroad spike in three-pronged chestnut between railroad and river, on up stream bank of ravine about ¼ mile above mile post 18.
148.15	917.606	East corner, north pier of Lumberport highway bridge. B. M., cut.
148.65	899.616	Railroad spike in sycamore, 1400 feet up stream from Ten Mile creek at Navigation Ripple.
149.15	911.427	Railroad spike in oak above mile post No. 20 near road crossing.
149.85	906.225	Railroad spike in oak between railroad and river, 75 ft. down stream from lower end of hotel, Cheswood Park.
150.55	923.142	S. E. corner upper wing wall, Maulsby highway bridge. B. M., cut.
151.15	907.459	Point on masonry, west corner, lower or river end of railroad culvert, 3,000 ft. up stream from Maulsby bridge.
151.55	923.174	On buckeye above railroad in second ravine above watch box, about 20 ft. from center of track, about ½ mile below Clark Station.
152.25	916.647	North corner east pier M. R. Railroad bridge across Simpson creek, Clark station. B. M., cut.
152.95	916.205	Railroad spike in large oak between railroad and river, 3500 ft. up stream from Simpson's creek.
153.25	924.737	Railroad spike in small hickory between railroad and river near road crossing and mile post 24.
153.45	937.638	Railroad spike in shale above railroad, opposite first telegraph pole below watch box, 900 ft. below Haning station.
153.75	917.675	Railroad spike in a four pronged black walnut on river bank 500 ft. up stream from Haning station.
154.25	920.408	Railroad spike in chestnut on river bank 900 ft. down stream from Griffith's run.
154.75	926.245	Railroad spike in sugar between railroad and river, near lower end of switch and 675 ft. down stream from lower end of coke ovens at Farnum mine.
155.25	922.407	Railroad spike in large oak between railroad and river, 1200 ft. up stream from Farnum railroad station.
.....	927.099	Railroad spike in buckeye between railroad and

Distance from mouth of river. Miles.	Elevation. Feet.	Station.
		river, near lower end of cut below Bartlett station.
156.45	932.904	River rail lower end of trestle No. 10, Bartlett station.
	924.280	Railroad spike in sugar between railroad and river, Bartlett station.
.....	936.374	On chestnut between railroad and river near dwelling of D. L. Hurst.
157.35	932.325	River rail, Glen Falls coal chute.
157.45	933.005	River rail, trestle No. 11, over Falls Run, lower end.
	933.328	River rail, trestle No. 11, over Falls Run, upper end.
.....	931.807	Railroad spike in sugar above railroad and public road, mouth of Falls Run (on Snake Hollow) above Glen Falls station.
.....	930.427	Railroad spike in sycamore between railroad and river, small railroad cut, about ½ mile above Glen Falls station.
.....	956.203	Railroad spike in oak above railroad, upper end heavy cut and curve in railroad.
158.95	951.585	River rail upper end heavy cut, 50 ft. down stream from small ravine, 1,000 ft. down stream from Crooked run.
.....	954.126	Railroad spike in ash between railroad and river, upper end railroad fill.
159.65	967.638	River rail on trestle No. 12, immediately over stream.
159.75	968.469	River rail, trestle No. 12, upper end.
	966.641	Point on masonry, immediately over tile drain, upper end railroad stone culvert, about 420 ft. up stream from trestle No. 12.
160.75	997.135	Point on west corner, north abutment, M. R. railroad bridge over the B. & O. railroad, opposite Adamston.
	970.584	Bolt head, north-west plumb post, B. & O. water tank, left bank, Adamston. B. M. of W. Va. S. L. Railroad.
	972.330	Up stream rail, B. & O. Railroad bridge over face of abutment.
	971.674	Up stream rail, B. & O. Railroad bridge over face of abutment on left bank.
160.85	941.782	Top of abutment, left bank, upper inside corner of Adamston highway bridge. B. M., cut.
161.35	926.005	End of timber of Hart's mill dam.
161.75	941.818	Lower inside corner, left abutment, highway bridge across mouth of Elk creek, Clarksburg. B. M., cut.
	945.049	Lower inside corner right abutment highway bridge across West Fork river, Clarksburg (bridge seat.)
	944.841	Lower inside corner left abutment highway bridge across West Fork river, Clarksburg (bridge seat).

Kanawha River.

CHARLESTON, W. VA., February 20, 1899.

DR. I. C. WHITE,
State Geologist,
MORGANTOWN, W. VA.

DEAR SIR:—In compliance with your request I take pleasure in handing you herewith a blue print profile of the Great Kanawha River from the mouth to Kanawha Falls, giving tide water elevations (Ref. mean tide at Richmond) of miter sills, sill of navigation pass, top of dam, coping of lock, lift of lock, original low water, etc., at each lock and dam on the river, extreme high water elevations, etc., with distances from the mouth of river. All of the lock and dam foundations are built on rock except No. 11 near the mouth of the river. No. 11 is built on hardpan, an indurated clay, from 18 to 24 feet below low water mark. A description of this hardpan is given on page 2452 of the extract from the Report of the Chief of Engineers herewith. The bed rock at this site is about 40 feet below low water, or 470 feet above tide.

Hoping this will answer your purposes, I am

Yours very truly,

ADDISON M. SCOTT,
U. S. Resident Engineer.

Distance. Miles.	Station.	Elevations above Tide.					
		Ext'e low water.	Sill of Lock.	Pass of Lock.	Pool above Dam.	Top of lock wall.	Extr'e high water.
0.0	Mouth of River	510.08	.....	.....	.....	.....	571.07
1.75	Lock No. 11	509.58	504.0	508.0	521.0	526.0	.....
11.50	Thirteen Mile Shoal	512.15	.....	.....	.....	.....	571.64
18.75	Lock No. 10	517.36	514.0	515.0	528.0	533.0	.....
21.50	Buffalo	519.96	.....	.....	.....	.....	572.22
25.25	Lock No. 9	523.64	520.5	521.25	534.25	539.5	.....
36.00	Lock No. 8	531.27	526.0	529.25	542.25	547.25	.....
44.25	Lock No. 7	539.63	535.5	537.5	550.50	555.50	.....
46 00	St. Albans	.....	.....	.....	.....	.....	591.28
54.50	Lock No. 6	548.01	543.75	546.50	559.00	565.50	.....
58.00	Charleston, Elk River	552.50	.....	.....	.....	.....	601.32
67.75	Lock No. 5	556.22	552.50	553.50	566.50	572.50	604.88
73.75	Lock No. 4	564,44	559.75	561.00	573.75	579.75	611.67
80.00	Lock No. 3	571.22	566.75	.....	585.75	601.25	622.63
85.00	Lock No. 2	581.77	578.75	.....	597.75	609.75	.....
86.00	Cannelton	586.34	.....	.....	.....	.....	632.17
95.25	Kanawha Falls, top	637.00					
	Bed-rock under Falls	590.00	.....	.....	.....	.....	.....
97.00	Gauley River / New River	650.20	.....	.....	.....	.....	665.50

Disagreement of Levels.

It is not to be expected that the levels of the several railroad lines of the State will be in exact agreement with one another or with the results given by the river surveys of the U. S. Engineers.

In order to determine the amount of this disagreement at some particular point, Clarksburg was selected, and Prof. T. M. Jackson, President of the W. Va. Short Line Railroad, kindly had the necessary levels carefully made, connecting the Baltimore & Ohio, and the West Va. Short Line with the levels of the U. S. Engineers, who have carried the Pennsylvania Railroad datum from Uniontown across to the Monongahela river at Lock No. 9, and up the same to Clarksburg. The point chosen for comparison was the Bench Mark of the U. S. Engineers at the "Bolt head, north-west plumb post B. & O. water tank, left bank, Adamston, 970.584 feet," according to the river survey above mentioned with the Pennsylvania Railroad datum. The same point (970.584 ft.) by the W. Va. Short line datum is 969.08 ft., and by the B. & O. datum of 1030 ft. for sub-grade of the old passenger station at Clarksburg, is 966.45 ft., thus giving a difference of (970.584—969.08) only 1.504 ft. between the Short Line Railroad datum and that of the Government Engineers, and (970.684—966.45) of 4.134 ft. between the latter and that of the B. & O., results much nearer in agreement than usually found when different railroad and river levels interlock.

Prof. Jackson also had the elevation of the new passenger station of the B. & O. R. R. at Clarksburg determined, which on the basis of 1033.49 ft. for the water table of the old passenger station under west

window (a bench accurately established from the B. & O. profile many years ago), gives for the top of the south rail at line of the east wall of the new passenger station an elevation of 1010.16 ft., and a bench mark on door step of the north-east door of the station building 1011.8 ft. Also the top of south rail at west end of the platform, Adamston station, B. & O. R. R., 961.15 ft., and for the B. & O. bridge seat across the North-Western Turnpike at Adamston, B. M., top of stone wall, south-east corner of abutment, 954.91 ft. The elevation of the new passenger station is given in the table on page 31, at 1,000 feet, while Adamston is 952 ft., both of which are too low by 10 feet approximately, even on the B. & O. datum of 1030 feet for sub-grade at the old passenger station. The four points on the B. & O. given above, brought into agreement with the Pennsylvania Railroad datum carried from Uniontown to Clarksburg by the U. S. Engineers, would be for the south rail at Clarksburg new station, 1014.294 feet; (for the bench mark on the door sill, same place, 1015.934 feet;) for the south rail at Adamston 965.284 feet; and for the bench mark on bridge seat over North-western Turpike, 959.044 feet, above tide.

NO INDEX.

As a substitute for an index the reader is referred to the Table of Contents which will in a measure supply that desideratum.

LIBRARY OF THE UNIVERSITY OF CALIFORNIA

14 DAY USE
RETURN TO DESK FROM WHICH BORROWED

EARTH SCIENCES LIBRARY

This book is due on the last date stamped below, or
on the date to which renewed.
Renewed books are subject to immediate recall.

LD 21–40*m*-5,'65
(F4308s10)476

General Library
University of California
Berkeley

U.C. BERKELEY LIBRARIES
C033852722

B136